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THE DUBLIN MEETING

A SPECIAL CORRESPONDENT of *The Times*, writing from Dublin during the Meeting, quotes an overheard conversation: 'Every second man a learned doctor,' said the old lady in the black coat, engulfed by a tide of scientists pouring out of Trinity into College Green. 'Sure,' said her friend, 'and I hope they've someone to pray for them, for they've an awful lot on their consciences.'

Whatever members had on their consciences all of them—and especially those who were visitors to the Republic of Ireland—had a great deal on their minds. Quite apart from the scientific programme which, by general consent, was agreed to be quite outstanding, there was all that Ireland itself offered: the unique quality of its people and its land with its lovely hills, magnificent coast-line, its rich archaeology and the ubiquitous memories of its turbulent and historic past.

To this was added the compelling attraction of Dublin itself as a meeting place.

> The seat of this citie is of all sides, pleasant, comfortable and wholesome [wrote the Elizabethan traveller Stanihurst in 1577]. If you would traverse hills, they are not far off. If champaign ground, it lieth of all parts. If you be delited with fresh water, the famous river called the liffie runneth fast by. If you will take the view of the sea, it is at hand.

Dublin is, indeed, no mean city and an ancient one. In remote ages there was a village where an ancient highway from Meath to Wicklow crossed the Liffey and this village became a Danish city some thousand years ago. In the intervening centuries Dublin has had much contact with science and scientific activities. Trinity College, long distinguished for its mathematicians, was founded in 1591; the Royal Dublin Society was founded in 1731 'for the advancement of agriculture and other branches of industry and for the advancement of science and art'; and the Royal Irish Academy in 1785. University College, Dublin, which had its origin in Newman's Catholic University (established in 1851), also incorporates the Museum of Irish Industry, later the Royal College of Science for Ireland, founded in 1845.

The Association itself is no stranger to Dublin. It was as far back as 1835 that it first came to the Irish capital after previous meetings at York, Oxford, Cambridge and Edinburgh. It returned to Dublin in 1857, 1878 and 1908. Of the first meeting it is recorded that in every respect, scientific and social, it fulfilled all expectations and, moreover, in quaint but expressive words,

> the silent undercurrent of refined and invisible hospitality by which the guests of Ireland found their expenses contracted and their cheer enhanced, were not ineffective in kindling a warmth of feeling by which the powers of the mind are capable of being invigorated, even in the pursuit of abstract truth.

How heartily we may echo today the spirit of these words written so long ago. For this year's Meeting was characterised by a charm and hospitality which, if not without parallel, can never have been surpassed in the long history of the Association. The undoubted success of the Meeting which, while it followed a traditional pattern, had a distinctively Irish flavour, must be attributed to the efficiency of local arrangements and to the local enthusiasm which was so generously displayed from the beginning of local preparations and continued undiminished till the end of the meeting. While the chief credit for this must lie with the Local Organising Committee, the contributions of the Association's very many other hosts—too many to name individually—must not go unremembered. The degree of success attained and the measure of the outstanding local interest aroused by the Association's visit to Dublin may perhaps be best—if somewhat inadequately—gauged

numerically: the total membership was 3,166, a figure well up to post-war levels of attendance. This total included 1,047 local members and some 800 student members. All those who were visitors to Dublin will surely agree that the Meeting proved to be for them a source of many happy memories of a most rewarding visit.

The President's first duty on the morning of Wednesday, September 4, was to attend the opening, in the Great Hall of University College, Earlsfort Terrace, of of the Agricultural Science Exhibition. The late Senator Sean Moylan, then Minister for Agriculture, said—in formally opening the exhibition—'The meeting here of the British Association and the reports of its activities, will do much, I hope, to bring home to our people, a knowledge of matters which now or in the immediate future, will affect them socially or economically'. The exhibition, which drew appreciative audiences during the week, offered a wide range of impressive and informative displays prepared by Bord Na Mona (The Turf Board); the Royal Dublin Society; the Department of Agriculture, University College, Cork: the Faculty of Agriculture, University College, Dublin: the Electricity Supply Board; Ceimici Teoranta and the Irish Sugar Company.

The President and other officers of the Association then attended an informal reception arranged by the Chairman and members of the Local Organising Committee to welcome those distinguished scientists from abroad who had honoured the Association by their attendance at the Meeting. The reception was followed by a luncheon given by His Excellency the British Ambassador.

The formal business of the Association was transacted during the afternoon of Wednesday, September 4, at meetings, in the rooms of the Royal Irish Academy, of the Council and of the General Committee. After the President had presented badges of office to the Presidents and Recorders of Sections, the General Committee proceeded to the election of Sir Alexander Fleck, K.B.E., F.R.S., Chairman of Imperial Chemical Industries Ltd., as President of the Association for 1958.

The Inaugural Meeting was held on the evening of Wednesday, September 4, in the Library of the Royal Dublin Society at Ballsbridge, where a distinguished assembly gathered to hear Professor P. M. S. Blackett deliver his address on *Technology and World Advancement* (*Adv. of Sci.*, Vol. XIV, No. 54, pp. 3–12). The Prime Minister, Mr. Eamon de Valera, was present, wearing his academic robes as Chancellor of the National University of Ireland. In welcoming his presence at the meeting, Professor Blackett remarked that, the 'British Association does not often have a Prime Minister on its platform and very seldom a Prime Minister whom, as a young mathematician in his own right, attended a meeting of the Association forty-nine years ago.' The Lord Mayor of Dublin, the Right Hon. Councillor James Carroll occupied the Chair, while short addresses of welcome to members were delivered by the President of University College, Dr. M. Tierney; the Provost of Trinity College, Dr. A. J. McConnell, and the Lord Mayor himself. The main audience filled the spacious book-lined library to capacity, while another audience watched the proceedings on six television screens in the adjoining Main Hall. At the conclusion of his Address, Professor Blackett was thanked by Sir Robert Robinson, O.M., F.R.S., Past President of the Association.

In presenting this vote of thanks, which was warmly supported by all those present, Sir Robert said that one did not know which to admire more, his courage in the outright expression of opinion, which might be a little controversial or the warmhearted generosity of his outlook and recommendations. He had seen the situation clearly and had developed logical arguments leading to an inescapable conclusion . . . the fact that he had chosen such a subject was clear proof of his conviction that the situation was desperate and that remedies must be sought without delay.

Two evening discourses were delivered during the week—on both occasions in the library of the Royal Dublin Society. It had been hoped that Professor O'Riordain

would speak on *Tara*, but alas, his untimely death intervened. Mr. G. F. Mitchell, Fellow of Trinity College, graciously agreed to speak in his stead and, on the evening of Thursday, September 5, delivered—to a large and deeply interested audience—a Discourse entitled *Ireland in antiquity—the chronological background*. His lecture, which was marked by a dry and lively humour and was generously illustrated by slides, discussed the various types of evidence used to date pre-historic objects discovered in Ireland. Dr. H. J. Bhabha, F.R.S., Chairman of the Indian Atomic Energy Commission and Director of the Tata Institute of Fundamental Research, Bombay, spoke on the evening of Friday, September 6, on *The economics of atomic power development in India and the Indian atomic energy programme* (*See* p. 159). On Monday, September 9, Sir Sydney Caine, K.C.M.G., Director of the London School of Economics, gave a public lecture in the Royal Dublin Society, to a large and representative audience, on *Education for Development* (*See* p. 191).

In the succeeding days the Sections, which were accommodated in the rooms of Trinity College and of University College, received a total of 289 communications—in some 60 sessions of which 9 were joint sessions of two or more sections. The appeal of the programme was increased by the fact that special attention was given to some of the growing points of science and to topics of broad public interest; for example, many aspects of cancer research were discussed, while the economists concerned themselves with problems likely to arise out of the European Common Market; there were many papers and sessions on agricultural and other topics of particular Irish interest; of the very many other subjects discussed, the following is but a bare selection: the industrial applications of thermonuclear reactions, Element 102, the structure and functioning of the nervous system, radiation and biology, photo-synthesis, bilingualism, and economic problems of the under-developed areas. That this year's Annual Meeting in Dublin 'amply justified itself again as a public forum for the projection of scientific ideas over the widest canvas of human activity,' may be evident from this necessarily short account of the programme. The feeling of a science correspondent, in summarising his views on the Meeting, at any rate was as follows:

> It is one of the more useful functions of the British Association that it makes visible not only the leaves and branches of the scientific tree of knowledge, but also some of its roots. And it is abundantly clear that the scientific revolution is only beginning.

In addition to the formal scientific sessions there were a number of first-rate exhibitions on view during the week which drew large and appreciative audiences.

In the Department of Chemistry, University College, Dublin, there was a fascinating display of beautifully constructed glass models which illustrated, amongst other things, atomic and molecular orbitals. Some extremely interesting historical material honouring William Higgins, first Professor of Chemistry in the Royal Dublin Society and Sir Robert Kane, Professor of Natural Philosophy in the Royal Dublin Society, was also on view.

An outstanding exhibition, entitled *Fifty years of Irish forestry*, was staged by the Forestry Division of the Department of Lands and the progress of State forestation in Ireland was brought to the notice of members by an array of attractively coloured charts and graphs. Particularly interesting was a display of soil-profiles with natural vegetation *in situ* and a very fine range of photographs illustrating timber crops. Other exhibitions in University College included a collection of medical photographs provided by the Institute of British Photography and a United Nations exhibition entitled *Ten years towards a better world* which took the form of photographs illustrating the activities of agencies of the United Nations in helping the less developed countries.

In Trinity College Library, there was an exhibition of books and manuscripts illustrating the history of science, including a special display of the works of

Professor Sir W. R. Hamilton (1805–65) and Professor John Joly, the centenary of whose birth occurs this year. In St. Patrick's College, Maynooth, there was a scientific exhibition showing manuscripts and equipment of the Rev. Dr. Nicholas Callan.

The National Museum of Ireland with its fine collections dealing with Irish antiquities, fine arts, folk-lore and natural sciences, and the Municipal Gallery of Modern Art, were also open to members during the meeting. In addition, Sir Alfred Chester Beatty graciously arranged a special opening of his library of rare Western and Oriental manuscripts.

In the Reception Room there was a comprehensive and most stylishly presented book exhibition prepared by the Irish branch of the Booksellers' Association of Great Britain and Northern Ireland. Over 5,000 books on scientific and technical subjects were assembled by their publishers. A collection of scientific books intended for the non-specialist reader, was displayed by the National Book League and attracted a great deal of attention.

The Scientific Films Committee of the Association once again organised daily screening of films. The programmes were arranged by Mr. E. Stafford, representing the British Universities Films Council and the films were screened in the Aula Maxima at Newman House. It is hoped to publish a full report of the film sessions in a later issue of this JOURNAL.

A leader writer on the *Irish Times* commented, at the close of the 1908 Meeting, 'the whirl of lectures and educational amusements is rapidly producing in the majority of us who are unaccustomed to being improved at such a breathless rate, a sort of mental indigestion'. Then, as now, there was obviously a need for some relaxation of the daily pressure of purely scientific affairs—relaxation which, in the form of social functions and excursions, not only refreshes members but provides invaluable opportunities for meeting informally with one another and with the residents of the inviting city. Dinners were arranged by twelve of the Sections and Section G (Engineering) were the guests, at a Conversazione held on the evening of Saturday, September 7, of University College, Dublin: the programme for the evening included a visit to the Engineering School. On the afternoon of Thursday, September 5, members were entertained at Arus an Uachtarain by His Excellency the President of Ireland. In spite of threatening clouds, there was no rain during the reception and guests were able to mingle on the lawns and enjoy the music of the Army Pipe Band. On Friday afternoon some 2,000 members were entertained at a reception held jointly by Messrs. Arthur Guinness, Son & Co. (Dublin) Ltd. and the Council of the Royal Zoological Society of Ireland in the grounds of the Society at Phoenix Park. On the evening of Monday, September 9, members were the guests of An Taoiseach, Mr. Eamon de Valera, at the magnificent State Apartments in Dublin Castle.

On Sunday, September 8, a large number of members were present at Mass, which was celebrated in the University Church, in the presence of the Papal Nuncio and His Grace the Most Rev. J. C. McQuaid, D.D., Archbishop of Dublin and Primate of Ireland. After Mass, the Archbishop held a reception in Newman House. The same morning at 11·15 Officers and members of the Association attended Divine Service in St. Patrick's Cathedral. Officers of the Association joined representatives of the Corporation of the City of Dublin, Trinity College, University College, the Royal Dublin Society, the Royal Irish Academy and the National Museum of Ireland, in a colourful procession in the Cathedral. His Grace the Most Rev. Dr. G. O. Sims, D.D., the Lord Archbishop of Dublin, during the course of his sermon, stressed very clearly the importance of what the Association was trying to do:

The Christian at his best, did not fear new discoveries, but saw the importance of playing his part in the ordering of them. The pursuit of science might be continued in

many countries and in varied climates, but they understood that the Association deliberately changed the venue year by year of its annual meeting in order that the knowledge which they offered, despite its universal character, might be delivered in local atmosphere, a local colouring for the furtherance of discussion and debate. Thus work which was carried out patiently, reservedly and at times unnoticed in studies and laboratories, could be interpreted and, in the right sense, popularised for people in their own surroundings, who looked for guidance in their responsibilities and so offered in turn their own particular experiences, as a contribution to the general pool of discovery.

Special Services were also held in the Presbyterian Church and the Methodist Centenary Church.

On the Sunday evening some 1,200 members attended a Symphony Concert in the Gaiety Theatre, arranged for them by their Dublin hosts. The concert, which was given by the Radio Eireann Symphony Orchestra, was conducted by Carlo Franci. A responsive and appreciative audience listened to a varied programme of music which included the very beautiful *Three Pieces for Strings*, by Professor T. C. Kelly, one of the younger Irish composers, and Tchaikowsky's Symphony No. 4 in F Minor.

On Tuesday, September 10, the President and other Officers of the Association, entertained to dinner at the Royal Hibernian Hotel, principal Local Officers and overseas guests. Mr. de Valera replied to the toast of 'An Taoiseach' and Dr. Paul Sears, President of the American Association for the Advancement of Science, to the toast of the overseas guests.

Members took full advantage during the week of a most attractive programme of general and sectional excursions arranged by the Local Committee—the most popular outings being, perhaps, those to Killarney, the Mountains of Mourne and Glendalough. Once again let a quotation sum things up:

> No doubt in bog and mountain many a leprechaun trembled at the sceptical minds let loose among the twilight mysteries of the west; but as a matter of fact most of the excursions have been busman's holidays. The botanists are making a long trip in the west to study the flora of its mild climate. Geologists look for the tertiary intrusive complex where most would see only the beauty of Carlingford Lough; zoologists watched the salmon leap at Leixlip, while physicists watched the stars from Dunsink Observatory.

The B.A. week, however, with its many preoccupations gives members scant opportunity to achieve more than a surface acquaintance with their new-found friends and surroundings. How valuable, therefore, was the gift to them by the Local Committee of a permanent record of their visit to the Republic of Ireland. This took the form of a beautifully printed and illustrated volume entitled *A View of Ireland* (or, 'Twelve essays on different aspects of Irish life and the Irish countryside'). In their preface Mr. J. Meenan and Prof. D. A Webb, the editors, say that the volume does not claim to be in any organised sense a scientific survey. Believing that the Englishman usually comes to Ireland to see something different to what he sees at home, the book concentrates on attempting to describe and explain those features of Irish life and the Irish countryside which are least familiar to him. The editors hope that they

> have spared the reader an overdose of celtic twilight and there is no harm in reminding him in the midst of his social and intellectual junketings in Dublin, that the creamery at the cross roads and the ass-cart full of turf, the monthly pig-fair and the Holy Well, are also part of Ireland. To prevent ourselves falling into the style of a tourist brochure, we have diligently kept before us the advice of that keen student of Irish affairs, Oliver Cromwell, and have done our best to paint our subject, warts and all.

In conclusion, it need hardly be said that the general arrangement made for the reception of members were first class. Dublin being a tourist city, the problem of housing visitors to the meeting presented no special difficulty. From the start the

skilled help and experienced facility of Bord Failte Eireann were put at the disposal of members who were accommodated generally in hotels and guest-houses in the city. Lodging was provided for younger people in University halls of residence and similar establishments. With such full days ahead of them it proved convenient for members to lunch each day, within the confines of the University area and they were most grateful, therefore, for being enabled to take their mid-day meals so expeditiously and pleasantly in the gracious surroundings of Trinity College Dining Hall and in the University College restaurants.

Coras Iompair Eireann most generously granted members free travel on city buses for the week of the meeting, a concession which was tremendously appreciated by all. The Local Committee provided each member with a most useful and informative Diary which made the task of planning the week's activity so much easier. Members met on business and pleasure in the Reception Room in the Mansion House—in the magnificent setting of the Round Room—a setting which was enhanced by the very lovely floral decorations which were renewed daily during the week. The Press Bureau was also established in the Mansion House, under the expert guidance of Mr. Leslie Luke, Press officer of Arthur Guinness, Son & Co. (Dublin) Ltd. The Association are greatly indebted to the latter for the provision of staff, equipment and other facilities without which it would hardly have been possible to provide for the servicing of this essential part of the Association's work. The outstanding quality of the Press service provided was reflected in the very full reports of the proceedings which appeared during the week in the press and on the radio, and subsequently in *Nature*, *Discovery*, *The New Scientist*, and other periodicals. A special tribute must be paid to the full and accurate daily coverage of the meeting provided by the local Irish papers. Rarely, as was agreed by correspondents themselves, at a press conference on the final day of the meeting, have the facilities offered them proved to be so all-embracing.

At their final session on Wednesday, September 11, the General Committee voted, with acclamation, that:

At the close of this memorable week in Dublin the General Committee, on behalf of all members of the Association, resolve to record their extreme indebtedness for all that has been done to make the Meeting a success and their very real appreciation of the unmistakable warmth of the welcome offered to the Association by the President and people of the Republic of Ireland.

The General Committee wish to convey the sincere thanks of the Association to the Prime Minister of Ireland, the Lord Mayor of Dublin, the President of University College, the Provost of Trinity College and their staffs, the Presidents and Councils of the Royal Dublin Society and the Royal Irish Academy, the Council of the Royal Zoological Society of Ireland, the Chairman and Directors of Arthur Guinness, Son & Co. (Dublin) Ltd., Radio Eireann and the proprietors of the Gaiety Theatre, the Directors of Bord Failte Eireann and of Coras Iompair Eireann, and their very many other hosts and colleagues for their great generosity and unqualified support.

Dublin is a city of great antiquity, learning and beauty: in such a setting the enthusiasm with which all members of the Association were received and the splendid efficiency of the arrangements could not fail to make this, its fifth meeting in Dublin, the outstanding success that it has been.

ON THE ECONOMICS OF ATOMIC POWER DEVELOPMENT IN INDIA AND THE INDIAN ATOMIC ENERGY PROGRAMME[1]

by

DR. H. J. BHABHA, F.R.S.

SINCE the end of the Second World War an increasing number of thinking people—scientists, economists and politicians—are devoting more and more of their attention to the problems of the underdeveloped areas, and it is significant that in his Presidential Address on Technology and World Advancement, Professor Blackett should have devoted much of his time to discussing the development of these areas. This interest in the underdeveloped countries of the world is understandable, for they comprise a major part of its land surface and contain a major part of its population. The development of these areas during the next fifty years and the form of this development may well hold the key to the progress of the world as a whole and to the establishment of an enduring peace.

It is perhaps also not an accident that the subject of my discourse should be on the economics of atomic power development in India and the Indian atomic energy programme, for atomic energy is the newest branch of technology, the one on which the industrial revolution of the twentieth century will be based, and it is naturally of vital importance to study what impact this new development can have on the industrialisation of the underdeveloped countries.

This Association was founded one hundred and twenty-six years ago, and its formation reflected the new outlook on science which arose then in the first society to feel the impact of the Industrial Revolution. Many of the fundamental discoveries on which the control of atomic energy is based were made in the United Kingdom, which leads again today in having the most developed and concrete programme for the utilisation of nuclear power.

The triumphs of Western science and technology during the last two hundred years were so dazzling, that they completely overshadowed the technical contributions of the earlier and much longer periods of history, which formed the basis and the starting-point of this triumphant development. They gave the West such a dominant position in the world during the last two centuries up to the beginning of the Second World War that one forgot the quite different picture of the world in relative technical advance which existed during the preceding twenty centuries and more. One has only to recall the number of fundamental inventions, such as the discovery of gunpowder, which came from China in the preceding centuries, and which left their impress on the subsequent development of civilisation, or remind oneself of the almost legendary pre-eminence of India in technology before the eighteenth century, for example in metallurgy and the quality of its textiles. To quote but a few examples, it is said that when Alexander the Great invaded India he was presented with a hundred talents of Indian steel, this being considered of a specially high quality. The famous Damascus Blades were made of Indian steel, and Verrier Elwin[2] quotes the Arab Edrisi as saying: 'The Hindus excel in the manufacture of Iron. They have also workshops wherein are forged the most famous sabres in the world. It is impossible to surpass the edge you get from Indian

[1] Evening Discourse delivered on Friday, September 6, in the Library of the Royal Dublin Society, at the Dublin Meeting of the British Association.

[2] *The Story of Tata Steel*, by Verrier Elwin.

steel.' A French traveller Tavernier, who travelled across India in the seventeenth century, remarked that the people in a certain part of India 'carry a broad sword like the Swiss. The barrels of their muskets are stronger than ours and the iron is better and purer.' Sir George Birdwood, in his *Handbook to the Indian Court*, recounts that 'Salamasius mentions that among the surviving Greek treatises was one on the tempering of Indian steel'. And visitors to Delhi today can still see a reminder of the technical excellence of Indian metallurgists of those days in the famous Iron Pillar, which is nearly twenty-four feet long, and was wrought in the third century A.D. by welding together discs of forged iron. The phenomenal advance in technology of the West during the last two hundred years completely changed all this, and it is the large and populated areas of India, China, and other countries of Asia, which once led in technology, which are now trying to catch up the advanced countries in technological development.

It is perhaps desirable at this stage to ask what one means by an underdeveloped country. I think one means essentially any country in which the *per capita production* is relatively small, and about a tenth or less than that of the countries described as industrially advanced. As an index of this production, one may take the income per head, or the total energy consumption per capita, or even the total steel consumption per capita. This labelling of countries as underdeveloped is important, because it emphasises a fundamental feature which they all have in common. It, however, obscures many important differences between them in other respects, differences which affect the relative ability of countries to undertake industrial development on their own, and their intrinsic technical potential.

The present population of India is about 390 million, let us say 400 million as a round figure. The production of any particular commodity, such as electric power or steel, has to be large indeed if division by this large figure is not to yield a small per capita production. Apart from being one of the two largest producers of textiles in the world, India today produces many industrial commodities, like steel, locomotives, trucks, aeroplanes, machine tools, heavy chemicals, and fertilisers, which are produced in very few underdeveloped countries. This fact gives it a technical ability to develop on its own, which is very different from that of most other underdeveloped countries. Conversely, it makes the production targets, which have to be reached in order to raise the standard of living substantially, so great as to make the problem one of enormous proportions. For example, a per capita production of electric power equal to that of the United States would require India to have an installed capacity of roughly two hundred and fifty million kilowatts. Similarly, an annual per capita steel production of the same order as that of the advanced countries of the world would require India to produce over two hundred million tons of steel annually. Since, as Professor Blackett has pointed out in his brilliant analysis, the development of the underdeveloped areas is first and foremost a problem of national saving and of new capital formation, a simple calculation shows the gigantic proportions of the problem.

At this point a remark would not be out of place on the views one often hears expressed to the effect that the underdeveloped areas should only undertake such developments as are possible in economic competition with the advanced countries, and that they should beware of embarking on so-called uneconomic enterprises for political or national reasons. A glance at the world as it is will soon convince one that developments in the past have not been determined solely by economic considerations and that political factors have played almost as great a role. Countries like India, China and Indonesia, which have quite considerable mineral wealth and natural resources, have remained underdeveloped, while on the other hand countries like Switzerland, with practically no mineral wealth or natural resources to their credit, except picturesque scenery, have attained as high a standard of living as practically any country in the world.

The development of the underdeveloped areas of the world will eventually produce enormous demands for power. As I pointed out in my Presidential Address to the Geneva Conference on the Peaceful Uses of Atomic Energy, if the entire present population of the world were to consume energy per capita at the same rate as the United States today, and we allow for a doubling of the world's population within the next hundred years, which is the least that we can expect, the known reserves of fossil fuels in the world would be exhausted in under a century. In this calculation no allowance has been made for the rise in the standard of living of the industrially advanced countries which will continue to take place for many decades at a very rapid rate. There seems little doubt that in due course atomic energy will eventually become the principal source of energy supporting civilisation.

Long-range need for Atomic Energy in India

The coal reserves of India have been fairly well estimated. They may be taken at roughly 40,000 million tons, to which coking coal only contributes 2,780 million tons, while the rest comes from non-coking coal. Thus, the total reserves of coal in the ground amount roughly to a hundred tons per head of population. This is less than one twentieth of the per capita coal reserves of China, roughly one thirty-fifth that of the United Kingdom, and about one one-hundred-and-fiftieth that of the United States. Moreover, the per capita consumption of energy in the United States is equivalent to the burning of some nine tons of coal per annum. The same per capita rate of consumption in India would correspond to the burning of some 3,600 million tons of coal per annum, and would therefore exhaust the coal reserves in about a decade. A doubling of the coal reserves would hardly make any difference to the long-range picture.

The total hydro-electric potential of India is estimated at between 35 and 40 million kilowatts. The total hydro-electric potential, when fully harnessed, would therefore hardly amount to one-tenth of a kilowatt of installed capacity per head of population. Much of this capacity is difficult and costly to harness. By comparison, the installed electrical capacity of the United States amounts to about 0·63 kilowatt per head, while it is 1·1 kilowatt per head in Norway. Another way of looking at the water-power resources is to note that an installed hydro-electric capacity of about 40 million kilowatts corresponds roughly to an annual consumption of about 120 million tons of coal, or barely a third of a ton per capita per annum. The water-power resources do not therefore materially alter the long-range energy picture either.

The present oil production of India is very small. A considerable effort in finding new reserves of oil has been made recently, and will continue to be made for many years. These efforts have met with some success. It seems unlikely, however, that they will radically change the long-range energy picture. One should remember that the world reserves of oil are a small fraction of its coal reserves.

We therefore come to the inescapable conclusion that the reserves of hydro-electric power and conventional fuels in India are insufficient to enable it to reach a high standard of living comparable even with the present standard of the industrially advanced countries.

The known Indian deposits of uranium ore containing more than 0·1 per cent uranium were till recently estimated to contain a total of some 15,000 tons of uranium. Much larger quantities of uranium are obtainable in ores of lower uranium content. A systematic survey for uranium in the country was only begun in 1949, while surveys by helicopter and aeroplane fitted with scintillometers and by other modern techniques have only been undertaken since 1954. They have led to a number of new finds of radioactive minerals, and have already doubled the known reserves of uranium.

India has been known for several decades to have one of the largest deposits of

monazite in the world containing over 9 per cent of thorium. It is estimated that these deposits on the south-west coast of India alone contain 150,000 to 180,000 tons of thorium in an easily extractable form. During the last six months the Raw Materials Division of the Department of Atomic Energy has made a spectacular new discovery of thorium- and uranium-containing minerals in the State of Bihar on the eastern side of India. This remarkable new deposit lies within ten feet of the surface and is estimated to contain over 300,000 tons of thorium in a concentration of over 10 per cent and over 10,000 tons of uranium in a concentration of over 0·35 per cent. Thus, the known reserves of uranium in ore containing more than 0·1 per cent amount to over 30,000 tons, while the total reserves of thorium amount to about half a million tons. Assuming that breeding in power reactors will be possible eventually, as seems likely, the known Indian reserves of uranium and thorium become equivalent in energy value to more than thirty times its reserves of coal. Thus, the advent of atomic energy radically changes the long-range power picture. The reserves of uranium and thorium are enough to support an annual per capita consumption of energy equal to that of the industrially most advanced countries for over three centuries. We may confidently expect that, long before this, technology will have advanced to the stage of enabling us to obtain energy in a controlled manner from fusion rather than fission. The energy problem of the world will then have been solved for all practical purposes for ever.

Energy Consumption

An estimate of the total energy consumption in India for the year 1953 was given in my paper to the Geneva Conference on the Peaceful Uses of Atomic Energy, and is given in Table I. The table also gives the estimates of the total energy consumption in India, the United Kingdom, and the U.S.A. made by Putnam for the year 1947. Putnam's estimates and those made on the basis of information obtained from the Planning Commission and the relevant Ministries of the Government of India agree quite well as regards the order of magnitude of the figures.

Table I

Total Energy Consumption

	1953		Putnam for 1947		
	India		India	U.K.	U.S.A.
	(10^9 kWh)	(10^{12} B.T.U.)	(10^{12} B.T.U.)	(10^{12} B.T.U.)	(10^{12} B.T.U.)
Coal	239	817	868	5,807	15,852
Hydro	3	10	—	4	286
Oil	43	147	89	559	15,735
Wood	23	78	134	—	1,780
Dung	1,000	3,412	3,002	—	—
Total	1,308	4,464	4,093	6,370	33,653

The table shows that the annual energy consumption of India was about two-thirds that of the United Kingdom and one-eighth that of the United States in 1947. Since the population was roughly eight and two-and-a-half-times that of the United Kingdom and the U.S. respectively, the per capita energy consumption is seen to be about a twelfth and a twenty-third of that in these two countries. The table also

shows that of the total energy consumption in India, roughly 75 per cent was provided by the burning of agricultural waste, and in particular cattle dung.

The annual coal production in India was about 34 million tons in 1951 at the beginning of the First Five-Year Plan. It became 40 million tons in 1956 at the beginning of the Second Five-Year Plan, and is expected to reach about 60 million tons by 1961. But the table shows that a doubling of the total energy consumption would require the coal production to be increased to six times the 1953 figure, or roughly to 216 million tons per annum.

The installed electrical capacity in India has risen fairly rapidly in recent years. It increased only by 56 per cent in the decade from 1940 to 1950, while it increased by 60 per cent during the period of the First Five-Year Plan (1951–6), and it is expected to double itself during the period of the Second Five-Year Plan (1956–61). In the industrially advanced countries, the installed generating capacity usually doubles itself every ten years. The growth of generating capacity in India during the next thirty years has therefore been estimated by the Planning Commission on the basis of the assumption that the capacity of the electricity supply undertakings will increase at the rates shown in Table II, which also shows the expected installed capacity at various periods during these thirty years.

TABLE II

Electric Generating Capacity

	Doubling period	Installed capacity (million kW)	
		3·5	March 1956
Second Five-Year Plan	5 years	7·0	March 1961
Third Five-Year Plan	6 years	12·0	March 1966
Fourth Five-Year Plan	8 years	25·0	March 1976
Fifth and subsequent five-year periods	10 years	50·0	March 1986

In this connection it is of interest to note that the total hydro-electric potential of India of 35 to 40 million kilowatts, even when fully harnessed, could only deliver a total amount of energy which is about a sixth of that obtained presently by burning cattle dung. There is, of course, an important difference, namely, that the energy obtained from burning agricultural waste is used only for domestic purposes, and does not assist industrial production. These figures, however, show in a striking manner the problem which will have to be faced if some 225 million tons of cattle dung, which is a most valuable manure, are to be put back into the soil annually instead of being burnt, and this domestic energy supplied from some other source.

PRESENT IMPLICATION OF NUCLEAR POWER

I come now to the much more interesting question concerning the relative economics of nuclear power in India today, and its bearing on the economy and planning during the next decade or two. In order to discuss this problem we have to make some assumptions about the capital cost of atomic power stations and the cost of electricity generated by them.

We are at the very beginning of nuclear power generation. There are a large number of basically different types of reactors which may be used for the purpose. They may differ from each other in the form of the fuel, the particular moderator used, if any, and the system used for extracting heat. The fuel may be natural or enriched uranium or plutonium, used either as a metal or an oxide, or in the form of a ceramic, or in a solution. The moderator may be graphite, or heavy water, or beryllium oxide, or there may be no moderator at all as in a fast reactor. Finally, the heat may be extracted by circulating some gas, or by an organic fluid, or by a liquid

metal; or indeed the fuel itself, if in the form of a liquid, may be circulated for the extraction of heat. It is readily seen that a very large number of combinations are possible, leading to reactors of basically different designs each requiring the solution of special engineering problems. Even though many of these possibilities can be excluded after careful theoretical consideration, the number of possibilities that seem feasible on paper is still so large that several have not been tried at all, at least on a large scale. A number of different prototype power reactors are being built in the United States, and a number of them have been planned in the Soviet Union. None of these, except the pressurised water boiler, is at the stage to provide firm figures for an economic study. For most of the others we have only the vaguest ideas regarding cost. The United Kingdom has concentrated on the development of the graphite-moderated gas-cooled reactor. The firmest figures regarding cost are available for this type. Our present studies of the economics of atomic energy in India are therefore based mainly on this type of reactor, though in certain cases other types have also been considered.

The latest experience appears to show that the capital cost of a 60-megawatt station might be about £150 (Rs. 2,000) per kilowatt of net electrical capacity, of a 150-megawatt station between £120 (Rs. 1,600) and £130 (Rs. 1,730) per kilowatt, and of a station with a net electrical capacity of 250 megawatts per reactor, perhaps £110 (Rs. 1,470) per kilowatt. We shall also assume in our discussion that power will be available at Rs. 0·044 to Rs. 0·05 (0·7 to 0·8 anna) per kilowatt-hour, that is between about 0·8*d*. to 0·9*d*. per unit. It is also important to note that actual fuel cost only accounts for about one-third of this cost of power, the remaining two-thirds being capital charges and interest on fuel.[1] These costs of power are based on taking capital charges at 13 per cent and a load factor of 80 per cent, corresponding to a utilisation of 7,000 hours per annum.

Any plan for the utilisation of an underdeveloped area must first ensure an adequate supply of power. An under-planning of the power requirements must be avoided in any case, since this would result in a throttling of the entire industrial development. It is preferable to err on the side of an over-production of electric power, since the capital investment in plants for producing power is usually small compared with the capital investment in industries needed to consume the same amount of power. For example, the capital investment in large power plants varies from Rs. 800 (£60) to Rs. 1,300 (£100) per kilowatt of installed capacity, whereas the capital cost per kilowatt of the consumer industries varies from Rs. 10,000 (£725) in textiles to Rs. 15,000 (£1,125) in engineering plants, which is roughly ten times as much.

The extent to which increased production of electricity is obtained from hydro-electric sources, from coal, oil, or natural gas, or even from atomic energy, must depend upon factors which vary from country to country, such as the available hydro-electric potential and the magnitude of investment required to harness it, the availability of atomic source materials, uranium and thorium, the industrial level of the country, and the availability of technically trained personnel.

If hydro-electric power is available from perennially flowing rivers or from water resources which can be harnessed by the construction of relatively small civil engineering works, it constitutes the cheapest electric power available. This power should be harnessed irrespective of other considerations, provided it lies in regions where the power produced can be utilised. However, in many areas of the world, and India is a notable example, the flow in rivers is seasonal, and hydro-electric power requires the construction of large and expensive dams. In many of the largest projects in India, the construction of such large dams is associated with

[1] By fuel cost we mean the cost of the fuel burnt. A much larger amount of fuel must, however, be put into the reactor in order for it to work, and interest must be charged on the capital cost of this fuel, which remains unburnt.

other objects, such as flood control and irrigation, and production of power is to some extent incidental. In such cases also the production of electricity may be very cheap, because operating costs are invariably very small and the capital charges are usually charged wholly or largely to some other head, such as irrigation or flood control. Nevertheless, the cheapness of such projects from the point of view of power generation is deceptive, since the power production cannot be undertaken without the necessary large expenditure on the associated civil engineering work, and the possibility of including such projects in a plan depends not so much on the power that is to be produced as on the other considerations involved. In any case, such projects are essentially an integrated whole and their inclusion in a given development period must make substantial drains on the available financial resources.

Table III shows the total capital cost of a number of hydro-electric projects which have either been completed or are under construction. The fourth column shows the capital cost per kilowatt of installed capacity.

TABLE III

Some Major Water and Power Projects

	Total cost (Rs. 10^7)	Purpose		Total cost per kW (Rs.)	Started	Completion
		Irrigation (Acres 10^6)	Power (MW.)			
Tungabhadra	60	0·83	99	(6,060)	1945	1961
Bhakra Nangal	174	3·6	610	(2,845)	1946	1959–60
Machkund	26	—	120	2,195	1946	—
Hirakud (Stage I)	71	0·67	123	(5,750)	1948	1957
D.V.C.						
(*a*) Tilaya	4	—	6	6,100	1950	1952
(*b*) Konar Dam	10	—	40	2,485	1950	1954
(*c*) Maithon Dam	17	(Flood control)	60	(2,790)	1951	1957
(*d*) Panchet Hill Dam	18	(Flood control)	40	(4,560)	1952	1958
(*e*) Durgapur Barrage	23	1·03 (and navigation)	—	—	1952	1958
Rihand	45	—	250	1,810	1952	1961–62
Gandhisagar Dam	22	—	92	2,440	1953	1959
Koyna	43	—	240	1,780	1954	1961
Periyar (Stage I)	7	—	105	640	1955	1958
Kundah	35	—	180	1,970	1956	—

It will be seen that in many of these projects, whose object is solely power generation, the capital cost per kilowatt is above Rs. 2,000 (£150), and even as high as Rs. 2,440 (£182). This is largely due to the fact that the rainfall in India is seasonal, being concentrated roughly in three months of the year, so that large and expensive civil engineering works have to be undertaken to provide the necessary storage capacity. Many of the projects are multi-purpose projects, and in all such cases the total capital cost per installed kilowatt is shown in brackets. The capital cost that is charged to power generation would clearly be much less, and is to a large extent arbitrary. The figures in brackets are, nevertheless, of interest since they show the total capital investment that has to be undertaken in a given period if any power is to be expected from the particular project.

Hydro-electric power is not uniformly spread throughout the country, and, as has already been mentioned earlier, is not really very plentiful. In certain regions of India, as for example in the south, most of the readily available hydro-electric

power will have been fully utilised by 1965, and other sources will have to be depended on for any further increase. Even in regions where some hydro power still remains to be tapped, the acute shortage of power and the time that is required to complete the dams for harnessing the hydro-electric power have compelled the construction of thermal stations. Thus, a thermal station of 120 megawatts has already been built at Trombay, near Bombay, and its capacity is being increased to 180 megawatts by the addition of a third unit. Thermal stations are also being built in Madras, in regions where there is still some hydro-electric capacity to be tapped.

The only alternative to hydro-electric power is the construction of thermal power stations using the fossil fuels, coal, oil or gas, or of atomic power stations. A few general conclusions regarding the applicability of atomic power in underdeveloped countries appear to follow from the figures which have just been given for the capital cost of atomic power stations and the cost of electricity generated from them.

These figures show that the capital cost of atomic power stations is 50 to 100 per cent higher than that of the most modern thermal stations. Other things being equal, one would expect the higher initial capital cost of atomic power stations to weigh against their use in planning the power programme for an underdeveloped country, since financial resources are likely to be fully extended and the necessary capital in short supply.

In the present stage of development, atomic power stations are more likely to be competitive with conventional thermal stations in power cost the greater their size. Stations of 100 to 500 megawatts would have to be considered. The total power consumption in a small underdeveloped country is small, and even if the total consumption is considerable in a large underdeveloped country, this consumption may be so dispersed in a number of widely separated areas unconnected with each other as to be ineffective from the point of view of providing a large concentrated demand. Most underdeveloped areas of the world are either not covered by electric grids, or have such grids only in the neighbourhood of a few large cities. Thus, the fact that at present atomic power becomes competitive with conventional thermal power only in large stations tends to limit the scope of atomic power stations in most underdeveloped countries, since such large blocks of power as 300, or even a 100 megawatts, can only be utilised, in general, if fed into a grid.

It should be noted further that, in the case of conventional thermal power, capital charges form a small fraction of the total cost, the main item being fuel cost. In the case of atomic power, on the other hand, the fixed charges constitute the major part, amounting to about two-thirds. For this reason atomic power stations are most economically operated on base load and most of the estimates of atomic power costs are made on the assumption that the power stations have a load factor of 80 per cent. An atomic power station would therefore be uneconomic unless it is connected into a grid or is provided a steady, large industrial load. The most economic use of an atomic power station would be to use it for carrying the base load in a grid in which the peak loads are supplied from conventional thermal stations. This consideration too would appear to make the use of an atomic power station in an underdeveloped country uneconomical.

I shall show now how all the general conclusions mentioned above turn out to be incorrect in the case of India. It has already been mentioned that the total hydro-electric potential of India is not very large and that the seasonal nature of rainfall requires the construction of large dams, which usually take many years to build, and makes its harnessing relatively costly. It follows that in many parts of India power is generated from thermal energy, even though the power generated from it may be more costly. There are three important factors the operation of which appears to make nuclear power competitive in a major part of India. They are, firstly, the geographical distribution of the coalfields, secondly the limited spare

1. CANADA–INDIA REACTOR

Fig. 1*a*.—One-million-gallon dump tank for the CIR cooling system.

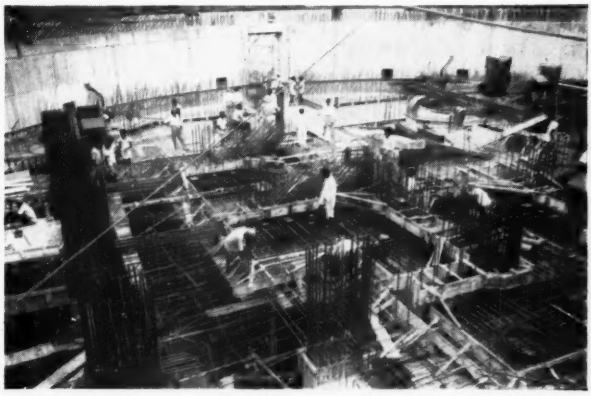

Fig. 1*b*.—Reactor basement slab reinforcement.

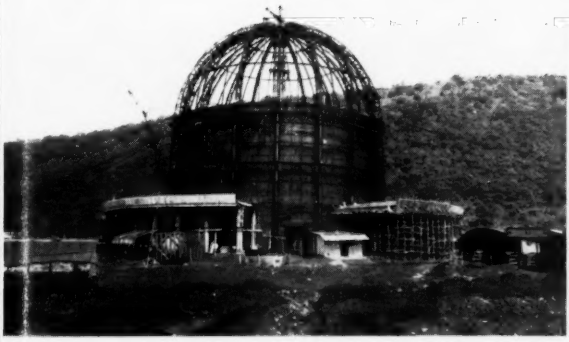

Fig. 1*c*.—Steel shell for housing the reactor. The annulus building contains the machinery and cooling system.

2. APSARA REACTOR

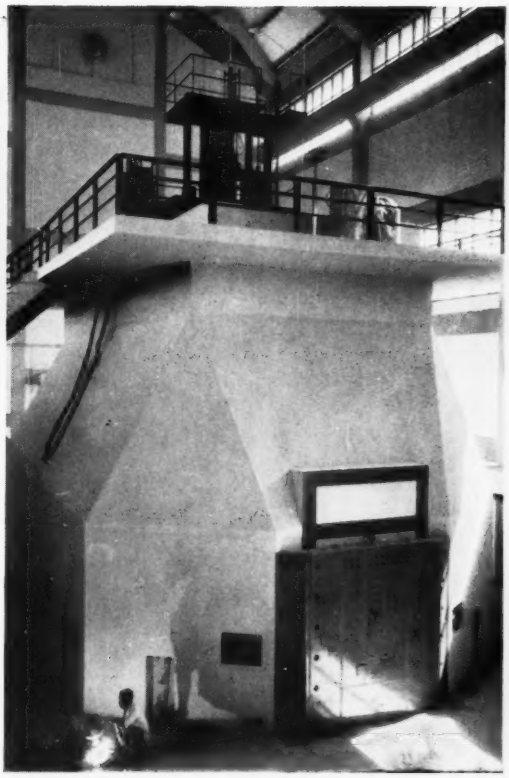

Fig. 2*a*.—View of reactor. The lead door for shielding of the thermal column can be seen in the foreground.

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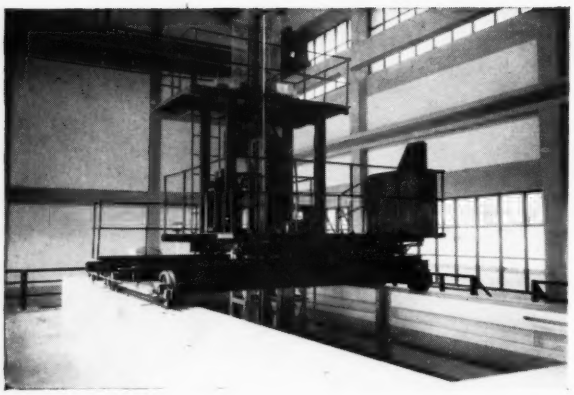

Fig. 2*b*.—The trolley supporting the core on which the control drives are also mounted.

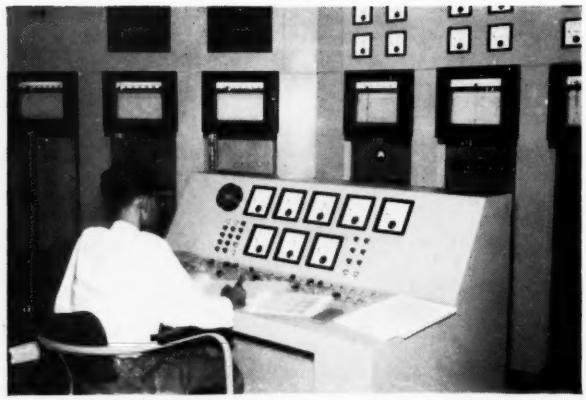

Fig. 2*c*.—View of control room.

3. THE THORIUM PLANT AT TROMBAY

transport capacity available in the railways, and lastly the great shortage of power in certain industrial areas. We consider the effect of each of these in turn.

Figure 4 shows a map of India with the principal coalfields marked on it and the estimated reserves of coal in each area. It will be seen from Table IV that 56 per

Fig. 4

cent of the total coal reserves are located in the States of Bengal and Bihar, in the eastern corner of India. Table IV shows also the production of coal from the principal coalfields in 1955.

TABLE IV

Coal in India

	Reserves		Production 1955	
	10^9 tons	Per cent	10^6 tons	Per cent
Bengal and Bihar	24·5	55·8	30·8	80·5
Madhya Pradesh	11·1	25·2	4·8	12·6
Andhra (Singareni, etc.)	4·0	9·2	1·5	4·0
Orissa (Talcher, etc.)	0·2	0·5	0·6	1·4
Other	4·1	9·3	0·5	1·5
Total	43·9		38·2	

It is seen that in 1955 about 80 per cent of the total production was in Bengal and Bihar, and all the coal for Delhi and Rajasthan in the north and west was supplied from these coalfields, over a distance of roughly 1,500 miles. The supply to these two areas will still come from the same coalfields in 1961, although the total amount to be transported will increase by over 50 per cent. A good part of the coal for the industrial areas of Ahmedabad and Madras is still supplied from Bengal and Bihar, and even when, at the end of the Second Five-Year Plan in 1961, a substantial part comes to be supplied from the other coalfields in the centre and south of India, the lead over which coal will have to be hauled will still be of the order of 700 miles and more.

The present price of coal at the pitheads varies from Rs. 15 to Rs. 21 per ton. The average tariff realised for transporting coal in 1955–56 on the Indian Railways was 2·85 hundredths of a rupee per ton per mile, while the average cost of carrying a ton of goods a mile for this period was 4·36 hundredths of a rupee, clearly showing that the transport of coal on the Indian railways is subsidised. The present tariff for transporting a ton of coal over 500 miles is Rs. 14·25, over 700 miles Rs. 16·50, and over 1,500 miles Rs. 24·88, whereas the actual cost of transporting coal over these distances based on the average cost of haulage given above is Rs. 21·68, Rs. 30·52 and Rs. 65·04 repectively. The real cost of coal from the Bengal–Bihar colleries in Rajasthan and Delhi is therefore over Rs. 80 per ton, as is its real cost today in Ahmedabad and Madras also. Even when coal comes to be supplied to the industrial areas of Ahmedabad, Bombay and Madras from the Central India coalfields at a distance of over 700 miles, the real cost of this coal will be about Rs. 50 per ton.

It is estimated that the cost of electricity from a thermal power station would be about 4·7 hundredths of a rupee or 0·85*d.* per unit with a coal cost of nearly Rs. 50 or £3·75 per ton. We should therefore expect power from atomic power stations to be competitive with power from thermal power stations in areas remote from the coalfields, such as Delhi, Ahmedabad, Bombay and Madras.

In planning for the future, we must also bear in mind the direction in which costs may be expected to move. Table V gives the range of pithead coal prices for the Bengal and Bihar coalfields during the last few years.

TABLE V

Range of Coal Prices—Bengal–Bihar coalfields

(In Rs./ton at pithead)

	Grade III 'B'. Run-of-mine, Dust coal and slack (Rs.)	Selected 'A'. Steam coal, rubble and smithy nuts (Rs.)
Fixed, 31. 5.1944	9·50	13·25
Revised, 14. 7.1944	9·31	13·31
Revised, 9. 7.1947	12·85	16·81
Revised, 21. 4.1949	10·56	16·81
Revised, 23.11.1949	10·56	16·25
Revised, 18. 2.1954	10·56	16·25
Revised, 18. 7.1955	10·56	16·44
Revised, 12.11.1955	10·56	16·44*
	—	16·62†
Revised, 5. 7.1956	13·56	19·44*
	—	19·62†
Revised, 8. 7.1957	15·06	20·94*
	—	21·12†

* Non-coking coal. † Coking coal.

It will be seen that coal prices, which are controlled, have risen by over 50 per cent during the last twelve years. On the other hand, atomic power may be expected to become progressively cheaper as a result of technical advances resulting in lower capital costs, higher temperatures of operation, and higher efficiencies. There is little doubt that during the next ten years nuclear power from improved versions of the graphite-moderated gas-cooled reactors will be cheaper than thermal power at most places in India remote from the coalfields.

I consider next the second factor mentioned above, namely the effect of the transport of coal on the railway system and the economy as a whole. The average tariffs for carrying one ton of coal and other goods over one mile is given in Table VI.

TABLE VI

Freight Charge per Ton-Mile on the Railways

	Rs./100
Coal for public railway	2·85
Coal for non-government railway	5·47
Grains	5·36
Oilseeds	6·72
Other commodities	6·67
Average cost	4·36

On the other hand, the actual cost of hauling a ton of goods a mile, taking interest on the total present capital invested in the railways at 4 per cent per annum, works out at 4·36 hundredths of a rupee. This clearly shows that the transport of coal is subsidised in the wider interest of the economy as a whole. Since, of the total ton-miles of goods carried by the railways, about one-third is coal, one can readily see the magnitude of this subsidy. It is clear that in future planning the transport of coal should only be done where it is essential, as, for example, where it is required for the metallurgical industries, and that any relief given to the railways in the transport of coal for power generation would result in a substantial saving to the economy as a whole. We shall return to the railways again presently.

Under-planning of power appears to have been a feature of the Indian economy during the last decade and more. For example, the shortage of power in Delhi is so acute that it has been decided to instal a number of diesel and steam generating sets giving a total capacity of 50 megawatts, a proceeding which must clearly result in high cost of power. Delhi and the north of Rajasthan State, and the western portion of the State of Uttar Pradesh, all form or will soon form part of a grid which would derive power eventually from the Bhakra Nangal Project, the total firm installed electrical capacity of which is just under 450,000 kilowatts. Power from the main dam will only begin to be available at the beginning of 1960, and all of it has already been earmarked, so that Delhi will not be able to get from this source the additional power which it is now felt this growing area will require after 1960. Such examples can be multiplied, and, indeed this state of affairs is generally true for the industrial areas of Ahmedabad, Bombay and Madras. Power is so short that new power is only sanctioned for certain purposes, and till recently the working of the textile mills was staggered. This shortage of power results in a remarkably high load factor for the grid systems as a whole. The average load factor for the Ahmedabad grid is 63 per cent, and that for the Bombay grid 69 per cent. Even on a conservative basis, therefore, it would appear to be quite feasible to have an atomic power station of a suitable size, say of 150 megawatts capable of being doubled later by the addition of a second reactor, at any of the areas I have mentioned, and operated on a very high load factor, keeping the present thermal stations for peaking and as stand-bys.

A Particular Example

It is instructive to consider a particular example in greater detail, and I take for this purpose the relative economics of an atomic and coal-fired power station of 150 megawatts located not far from Ahmedabad. As we have already seen, the cost of coal at the station, even if it were brought from the nearest coalfields in Central India, would be nearly Rs. 50 per ton, if its transport were not subsidised. At this price for coal the real price of electricity would be 4·7 hundredths of a rupee or 0·85*d.* per unit with capital charges at 13 per cent. The real price of electricity may actually be higher because of loss of coal in handling and due to pilferage in transit.[1]

The capital cost of an atomic power station of 150 megawatts might be taken roundly at Rs. 25 crores (£18·75 million), while the cost of a coal-fired station may be taken at Rs. 15 crores (£11·25 million). Thus the atomic station will cost Rs. 10 crores (£7·5 million) more in capital investment. To this must be added the investment in uranium, which may be taken at another Rs. 5·6 crores or £4 million. The total difference in capital required is therefore about Rs. 15 crores or £11·25 million. This, however, is not the whole story, and we have to look further into the relative costs of the two to the economy as a whole.

A coal-fired station would require about 1,300 tons of coal per day, assuming that a pound of coal is required for the generation of a unit of electricity. The station would therefore consume over 450,000 tons of coal per annum, the transport of which over a distance of 700 miles would mean a permanent locking up of 1,200 wagons and nearly 20 locomotives, representing a capital investment of Rs. 2·2 crores or over £1·6 million. The transport of this coal would utilise on the railways 300 million ton-miles per annum of carrying capacity. We have to make some estimate for the saving which would result to the economy as a whole if this transport of coal were saved by replacing a coal-fired by an atomic power station. There are two ways of doing this calculation. Since the average cost of a mile of railway track is Rs. 550,000 (£41,000), while the maximum carrying capacity of a mile of single track is 6·1 million ton-miles per annum, one could charge roughly Rs. 100,000 (£7,500) as the capital investment on railway track for a carrying capacity of one million ton-miles of goods per annum. The capital chargeable on account of track for the above coal transport therefore amounts to roughly Rs. 3 crores or another £2·2 million. Another way of looking at the matter is to calculate the increased earnings of the railways, which would result if the same carrying capacity were used for the transport of other goods at the rates given in Table VI above, instead of in carrying coal. These would be in two parts: first, the saving in subsidy on the transport of coal, and secondly, the additional revenue accruing to the railways on diverting this capacity to the transport of other commodities. The saving in subsidy amounts to Rs. 0·63 crores. The weighted average of revenue for carrying grains, oil and other commodities is 6·54 hundredths of a rupee per ton-mile for the year 1955–56. As the average cost of carrying goods per ton-mile is only 4·36 hundredths of a rupee, the net revenue to the railways under this head would be Rs. 0·65 crores. So the total increase in the earnings would amount to Rs. 1·28 crores or £960,000 per annum. If one assumes that the increase in railway capacity would have to be undertaken in any case for development purposes, the increased earnings on the railways, due to the substitution of the coal traffic required for a coal-fired station by general goods traffic, can be regarded as interest on the extra capital investment required by an atomic power station, which we have seen to be about Rs. 15 crores or £11 million. This would therefore represent a return on capital of nearly 8·5 per cent *over and above* the interest on

[1] For example, the Railway Fuel Economy Enquiry Committee (1953) estimates this at 7 per cent for coal consumed by Indian Railways.

capital at 5 per cent, which is already included in the cost of power from an atomic power station.

In calculating the relative costs of atomic and coal power to the economy as a whole, we have to carry the analysis further and work out the relative capital investment required to produce the 50 tons of uranium per annum needed by the atomic power station or the 450,000[1] tons of coal required by the coal-fired station. At 50 per cent overall recovery and assuming a pessimistically low-grade ore containing 0·05 per cent uranium, some 200,000 tons of ore must be mined. The next table gives the relative capital investment required for mining an additional million tons per annum of coal and of washing it, compared with the capital investment required for mining the equivalent amount of uranium ore, of extracting the uranium from the ore, of purifying it, and fabricating it into fuel elements.

TABLE VII

Relative Capital Investments in Producing 1 million tons of Coal or 110[2] tons of Uranium

(Rs. in crores)

	Coal	Uranium
Mining	3·5	1·5
Washeries	1·2	
Uranium processing and fabricating facilities	—	3·5
	4·7	5·0

Note: An overall recovery of only 50 per cent assumed in the uranium plant, requiring about 450,000 tons of 0·05 per cent ore to be mined.

The table shows again that the capital investment in the additional annual production of coal is comparable with the capital investment in the additional production of uranium. It would be substantially more with a richer uranium ore.

The example just given is typical of the situation which we find in many important industrial centres in India which are remote from the coalfields, such as Delhi, Bombay, and Madras.

UTILISATION OF THORIUM

It has been mentioned that the total reserves of thorium in India amount to over 500,000 tons in a readily extractable form, while the total known reserves of uranium are less than a tenth of this. The aim of a long-range atomic power programme in India must, therefore, be to base the nuclear power generation as soon as possible on thorium rather than uranium. Once concentrated fuel in the form of uranium 235, or uranium 233, or plutonium, is available, it should be possible to generate power in breeder reactors which breed more fissionable material, uranium 233 or plutonium, in the source materials thorium and natural uranium, than they burn. The reactor at Dounreay is a large-scale experiment in this direction, and if it succeeds in breeding, and at the same time is shown to be safe and easy to control, it should open up a new chapter in the generation of atomic power. There are other possibilities of breeding, as for example with heavy-water-moderated reactors. Since all power reactors intended for breeding appear to require the use of enriched or pure fissionable material, a self-sufficient programme must provide for the production of such material.

[1] This will be higher by 7 per cent, if the Railway Fuel Economy Enquiry Committee's figure for loss in transit and handling is accepted for coal transport in general.

[2] This will be less by 7 per cent if the loss in coal transport is taken into account and reduces the investment figure to Rs. 4·65 crores.

As far as India is concerned, we consider isotope separation plants for the production of uranium 235 by the presently known methods out of the question, due to their high cost, and even more because of their enormous consumption of electric power. The best way of obtaining fissionable material appears to be to produce plutonium as a by-product in atomic power stations working on natural uranium. A simple calculation shows that a million kilowatts of installed electrical capacity in nuclear power plants would yield approximately 900 kilograms of plutonium per annum. This could be used to fuel the second stage of atomic power stations intended to breed, and which could therefore be fed thereafter only with thorium. The plutonium produced in the natural uranium nuclear power plants would therefore be used to instal new electrical capacity each year. The amount of new electrical capacity which could be started off annually, to be fuelled from the plutonium produced in natural uranium reactors having a million kilowatts of electrical capacity, would depend on several questions, the answers to which are not known or not known sufficiently accurately. One must await the results of the experiments which are being done in the United Kingdom, the United States, and the U.S.S.R. on large-scale experimental power plants before reasonably accurate planning is possible. The Department of Atomic Energy is at present engaged in working out various possible power programmes with different assumptions regarding the data required.

It seems likely that breeder power stations may begin to operate by about 1965. In order that enough plutonium should be available at that time for fueling such stations, it is clearly necessary to start on an atomic power programme based on natural uranium reactors very soon. If the construction of such reactors were to be taken up next year, they would only begin to operate in 1962, and plutonium would therefore only become available in quantity by 1965.

The Indian Atomic Energy Programme

I will now conclude by telling you briefly about the work that is being done in India to develop atomic energy as a source of electric power and to promote its use in agriculture, biology, and medicine. On the industrial side we intend to produce all the materials required for a full atomic power programme. For this reason, we started by setting up a plant at Alwaye in South India to treat the well-known monazite sands on the west coast. In addition to producing rare earths and trisodium phosphate, a cleaning material sold in the market, this plant produces a cake containing thorium and uranium. This cake is brought to the plant at Trombay near Bombay, which produces a very pure thorium salt and also an uranium salt. It was built by our own scientists and engineers and has been in operation since 1954. Its capacity was increased six-fold last year.

We have designed a small uranium plant which will turn this uranium salt into reactor-grade uranium metal, and we expect to have this plant in operation by the middle of 1958. This plant will give us enough uranium metal for experimental purposes and for use in the reactors that are under construction at present. It will also give our scientific and technical staff the necessary experience for the design and construction of the large uranium plants which will be required by a full atomic power programme.

A small plant for the fabrication of fuel elements has also been designed, and its construction is being undertaken forthwith. Besides producing the fuel elements for our present natural uranium reactors, it will also enable research and development work to be carried out on new types of fuel elements and their canning.

India is one of the largest producers in the world of the rare mineral beryl from which the metal beryllium can be obtained, the present annual production being several thousand tons of high-grade beryl. Beryllium oxide may have interesting possibilities as a moderator, and the metal or one of its alloys holds out great

promise as a canning material. A large pilot plant for producing atomically pure beryllium oxide of nuclear purity and sintering it into bricks is also being designed. Its capacity will be about 15 tons of beryllium oxide per annum, but it will be capable of expansion to several times this size. Preliminary studies indicate that the cost of beryllium oxide produced in this plant will be lower than the cost at which it is being produced in Europe at present.

We also intend to produce heavy water in quantity, and the decision was taken two years ago to produce heavy water and fertiliser together in a large plant which is being built at Nangal in the north. This plant will produce over 340,000 tons of nitrogenous fertiliser annually, and between 10 to 20 tons of heavy water. Hydrogen for the ammonia plant will be made electrolytically. The heavy hydrogen will be concentrated in the last stage in the electrolysis cells, which will be arranged in cascade. The heavy hydrogen from these cells, which will comprise between 20 and 40 per cent of the total stream, will be liquefied and the deuterium extracted by the hydrogen distillation process. The plant has been placed at Nangal, so that it can draw cheap power from the dam at Bhakra. It will consume 160,000 kilowatts of electric power, and cheapness of power is essential for the economics of the process. It is estimated that by charging to heavy water only the direct costs involved in its production, the cost of heavy water will be about $20 per pound, which is substantially lower than the present world price. Production will commence in 1960. Several other large fertiliser plants are expected to be constructed during the Second Five-Year Plan, and it is the intention of the Government to produce heavy water in all of them.

We are also studying the erection of a plant to make atomically pure graphite from the coke produced in a refinery in Assam. Experiments which are under way at the Atomic Energy Establishment at Trombay have already shown that graphite of a high density can be produced by a method which is being tried.

Zirconium is another metal which has promise as a canning material. In order that it should be so used hafnium has at first to be separated from it, and quite a good deal of research work has been done on the separation of hafnium from zirconium. A process is now being tried out which is even more promising than the one reported by us at the Geneva Conference on the Peaceful Uses of Atomic Energy. This method promises to yield metallic zirconium free from hafnium in one step. Zircon, the mineral from which zirconium can be obtained, is found as a constituent of the famous beach sands on the south-west coast of India and is available in plentiful supply.

Any country which does not wish to depend wholly upon outside aid must have its own research and development organisation, not only for investigating the many possibilities which remain unexplored, but also because, even in fields where general knowledge is available, practical experience and detailed know-how have to be obtained. The Atomic Energy Establishment at Trombay, near Bombay, which was formally inaugurated by the Prime Minister in January this year, is India's centre for research and development in the field of atomic energy.

A layout of the entire Establishment has been prepared, and some buildings completed, while the construction of others will start very soon. Some of the new laboratories will be ready early next year, although all the buildings planned at present will not be ready till 1959. The Establishment is located at Trombay, some fifteen miles from the centre of Bombay. The site of the Establishment, which covers an area of over 2,000 acres, is completely separated from the rest of the industrial area of Trombay by Trombay Hill on its west. Its eastern side lies on the upper reaches of Bombay Harbour.

We did not wait for the new buildings to be completed before starting the research activities of the Establishment. The Physics and Engineering Divisions were located in the Tata Institute of Fundamental Research at the old Yacht Club building, and

in war-time hutments on its new site at Colaba. A warehouse in another part of Bombay was converted for housing the Chemistry Division, while the Biological and Medical Divisions were set up at the Indian Cancer Research Centre. The total scientific and technical staff of the Establishment is now about 300, and it will increase to over 800 by 1959. By that time the total number of workers on the site, including administrative, maintenance and worskshop staff, will be over two thousand.

To ensure a steady supply of trained scientific and technical personnel, we have started a training programme under which 250 young graduates and engineers will be recruited annually from the universities and given supplementary training for a year to fit them for work in our atomic energy programme. The first course commenced in August this year with 170 trainees. It is hoped to increase the intake of this school to 350 a year in due course.

Apsara, India's first atomic reactor, of the swimming-pool type, reached criticality for the first time on August 4 last year. It is the first reactor to go into operation in Asia, outside the U.S.S.R. It was designed, engineered, and built entirely by our own people and by Indian industry, except for the fuel elements. The fuel elements, which contain enriched uranium, have been provided by the United Kingdom Atomic Energy Authority.

The decision to build this reactor was taken in April 1955. A firm decision on the basic design was made in August 1955, and it took about one year to complete its construction.

As soon as the decision to build the Swimming Pool Reactor was taken in early 1955, we gave our attention to the next step of building a powerful high flux reactor for engineering research. We were considering several different types, when we received a generous offer from the Canadian Government to set up a reactor of the NRX type in India. The decision to proceed with the joint project was taken in August 1955, and the ground for it was broken in February 1956. We expect this reactor to be completed by the end of 1958. This reactor requires some twenty tons of heavy water, which was sold to us by the United States Atomic Energy Commission.

A short while ago, we decided to build a third zero energy reactor, which will enable us to study the effect of different lattices, shapes and sizes of fuel elements, mixed lattices containing uranium or plutonium and thorium, and so on. We expect to have this reactor in operation in 1958 also, and indeed, it may be the second reactor actually to go into operation in India.

The immediate need in many parts of India is for small power stations of 20 to 50 megawatts, and it is our intention to study for this purpose reactors moderated with beryllium oxide, gas-cooled, and working on natural or slightly enriched uranium. Since the critical size of beryllium-moderated reactors is smaller than graphite-moderated ones, preliminary calculations show that they may well be more economical in the power range below about 20 megawatts. For this purpose, we have had for some years a joint project with the Commissariat à l'Énergie Atomique for studying the properties of beryllium oxide as a moderator. A small group at our Trombay Establishment is now actively engaged in feasibility studies on beryllium-oxide-moderated reactors of a power output below 30 megawatts.

The Indian atomic energy programme is of a very modest size, compared with the programmes in the United States, the Soviet Union, and the United Kingdom. It has no military component, and I cannot but recall on this occasion the words of the Prime Minister, Mr. Nehru, at the inauguration of the Trombay Establishment, when he said, 'whatever might happen, whatever the circumstances, we shall never use atomic energy for evil purposes'. Although the Atomic Energy Commission was established as an advisory body in 1948 in the Ministry of Natural Resources and Scientific Research, an important effort to develop this work was not made

until a separate Department of the Government of India with the full powers of a Ministry was established in August 1954. Since then the work has developed very rapidly and the expenditure on atomic energy has grown about thirteen-fold within three years. Only a modest beginning has been made, but one that holds out promise of important developments, which may well help to accelerate the industrialisation of the country.

Before I conclude, may I add a few general remarks. Our preliminary, and as yet quite incomplete, study has shown that, contrary to the general conclusions one might expect to be true regarding the applicability of atomic energy to underdeveloped countries, due to the peculiar conditions obtaining in India atomic energy may be expected to provide that primary necessity of all industrialisation, electric power, with less burden to the economy than coal in regions remote from the coalfields. As we have seen, these regions constitute the major part of India. Although the economic burden may be less, it still remains of the same order of magnitude. Moreover, as I have pointed out at the beginning of this discourse, the capital investment required for the industries which utilise power is many times that of the industries which produce it. Since technical know-how and equipment can be bought, and, indeed, India will herself be able to provide the former within about five years, the main problem becomes that of finding the money out of savings required for rapid industrialisation.

We have also seen that due to the size of the population, the long-range problem of industrialising India is one of such colossal proportions that the money and effort for it can only come from within the country. Where external aid could be of importance is at the beginning, when internal savings are most difficult, and the total sum needed is relatively easy to find for the advanced countries. External aid could be of crucial importance during this initial period of ten or fifteen years in giving the 'assisted take-off into sustained growth'. This aid does not need to be a gift. It could preferably be in plant and equipment supplied on long-term credit.

India, and our great neighbour China, have the one common aim of raising the material standard of living of their people as quickly as possible. They are each doing this within the differing economic and social frameworks of their two systems. As has been pointed out, even with a gross new investment of 10 per cent per annum and a rise in the standard of living of $3\frac{1}{2}$ to 5 per cent per annum, the absolute gap between the underdeveloped and advanced countries must continue to widen for many decades. The only way of moving faster would be to allow no rise in the standard of living at all for the initial period and to plough back the increased earnings into new investment. The new investment might, therefore, be 10 per cent in the first year, say 15 per cent in the next, $22\frac{1}{2}$ per cent in the next, and so on. Twenty-five per cent may be the limit to which one can go in this way. Such a programme might perhaps be possible in an authoritarian society. In the democratic form of society, to which India is wedded, it would be wellnigh impossible.

As has already been pointed out, the money and effort for the long-range industrialisation of India can only come from her own people, but external aid at the beginning could be of importance in offsetting the initial advantage which an authoritarian society has, and in getting her off to a good start.

RESEARCH COMMITTEES, 1957–58

Grants of money, if any, from the Association for expenses connected with researches are indicated in heavy type.

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TECHNICAL ASSISTANCE AND IDEALISM: MISGIVINGS—AND MISTAKINGS[1]

by

ALEC DICKSON, M.B.E.

I READ a summary of Professor Blackett's Presidential Address some four days ago in a Chinese-owned English-language paper, published in colonial Hong Kong, whilst flying in an America plane over independent India. This was perhaps an appropriate setting against which to reflect on international aid on a global scale for the under-developed countries. As the title and theme of my own paper were chosen many months ago, I may be forgiven for remaining in the air a little longer to consider Technical Assistance and Idealism, before coming down to earth to make observations regarding Fundamental Education in particular. For although Fundamental Education may, administratively, be but a very small part of Technical Assistance, I believe that its significance is deeply bound up with the content and philosophy of international aid.

Let me say at once that I too believe that we should give, and give to the maximum of our ability. My concern is that we should give in such a way that *those whom we help should in turn give to others*—whether in passing on what they receive, as Governments, to their own people, or to neighbouring peoples even more in need than themselves; or, more specifically in the field of Fundamental Education, by the student *élite* contributing to the uplift of an illiterate peasantry. My hope is that we should not allow consideration of what might ideally be done in the future to blind us to what could be done now. My conviction is that we should think hard and imaginatively about the contribution that best lies in our power to give, today, in 1957: this may not necessarily be in cash, on a gigantic scale, but in personal service of the highest possible quality.

To me, the significant thing about the Presidential Address, with its appeal for massive financial help to the Have-nots, is that it should come at a time when America is going through an agonising appraisal of its Foreign Aid Programme. Many of the objections being raised against that programme may seem to us here to be of a party-political kind, or to stem from a natural, human reluctance to part with money. But in any one country the United States' Point-Four Programme is double that of F.A.O., W.H.O., I.L.O. and U.N.E.S.C.O. put together: and the United States contributes, additionally, about one-half of the funds of those U.N. Specialised Agencies. We cannot ignore the reasons that have led to such a retreat from their idealism of only a few years back—particularly when this disillusionment about the working of international aid in under-developed territories is shared by many working in the field, I repeat, *in the field*, of U.N. Technical Assistance. I am not thinking now in terms of those anecdotes, true and telling though many of them are, of tons of scientific equipment rusting on tropical wharves because no one locally is competent or concerned to take delivery of them, of U.N.I.C.E.F. milk being fed to cattle because native mothers and children dislike its taste, or of prize boars delivered under the Colombo Plan for special breeding being consumed at banquets for foreign V.I.P.s. A century ago, in the Crimean War, we ourselves were responsible for similar things: indeed, even more recently, if one remembers the Groundnuts Scheme.

[1] Paper given to Section L (Education) on September 10, 1957, at the meeting of the British Association in Dublin.

It is not these instances I have in mind, but certain incompatibilities of thought. The first is between the concept of large-scale international aid on the one hand, and of national sovereignty on the other—between inter-dependence and independence. Millions can be given in the hope that they will be used to finance development or investment—but we have little means to ensure that they will be so spent. We can give—but we have virtually no say in the spending: in that sense, massive financial support comes too late, for with independence there is relinquished the chance to ensure that money given for a particular cause will in fact be used to further that cause.

It is sometimes overlooked that under-developed territories tend to have under-developed governments: names of countries, some in the Middle East, come to mind, where it is certainly not lack of funds that hinders progress. In such places, government—quite simply—is power: and those who have it show little readiness to share it. It is a condition of U.N. Technical Assistance that aid can only be given through governments—and at the request of governments. Read, I would urge you, Vincent Cronin's poignant book, *The Last Migration*, describing the fate of a tribe in Southern Persia, nomadic since the beginning of time, for whom resettlement was decreed. Having myself been in charge of a Fundamental Education project in a resettlement area in an adjacent country—a project that never in its four years of frustrated existence received a visit from the Minister of Education or the Director-General—I can testify to how true and fair is the picture so movingly drawn by Cronin.

Then there is what I would regard as a second incompatibility—between the ideal of international assistance and the policy of neutralism. The first surely implies a concern for others, a commitment to their aid, an awareness that to overcome evil the good must be strengthened. Can this be reconciled with an attitude of disassociation from the affairs of others? Does this attitude of self-imposed moral quarantine entitle those who hold it to receive?

In a conference in Berlin last year, of the World Assembly of Youth, an element among the young delegates from overseas constantly demanded gigantic financial assistance from the West—not specifically for the relief of poverty or for investment of any particular kind—but quite simply as a right, as retribution for what they regarded as the exploitation practised by the West. One speaker, a former colleague of Dr. Ralph Bunche's, at the United Nations, previously an economist and now the most distinguished African civil servant in Ghana, propounded the dual thesis that economically it would be more accurate to describe Belgium as a dependency of the Congo's, and that Holland was under a continuing obligation to finance development in Indonesia, in view of the profit she had derived in the past from the Dutch East Indies. 'No strings attached' was the constantly reiterated phrase. I must confess I found this unedifying. We ask for guidance in a famous prayer, 'to give and not to count the cost'. But to *take* and not to count the cost would seem to combine the probabilities of bankruptcy and blackmail.

Most social workers agree today that indiscriminate charity is not the answer to the relief of poverty: theory and practice in community development condemn the uncritical doling out of grants as being likely to kill local initiative: I do not believe it to be basically different in international assistance. When there is little or no relationship between national effort and national revenue, between what is sown and what is reaped, an attitude is engendered that is neither particularly attractive nor reassuring: there is a basically healthier air in the comparatively poor territory of North Borneo compared with that in the adjacent oil-rich state of Brunei.

A situation has come about in Asia today where it is those who do *not* bring gifts who are regarded with suspicion. A recent writer in *Figaro* has described this as 'le droit au dollar'. The bitter irony of this situation, in the field of developing nations, was surely reached last year when *not* giving funds for the construction of the

Aswan Dam did more to create a sense of united nationhood in the Nile Valley than had the money been granted. A reaction against becoming 'remittance-men' of the West is on its way: it may take crude forms at times, but I find it very understandable. Basic to human pride and to national *amour propre* is the desire to be wanted, to feel that one has something to give. Egypt and India derive more satisfaction, I believe, from providing experts (as they do in quite large numbers) to other countries under U.N. Technical Assistance, than from receiving them. Last December the lepers in an institution in Sarawak—Chinese and Dayak and Malay, sharing little in common save their poverty and their disease—contributed £5 for the relief of Hungarian refugees. I have little doubt that learning that there were others, white men, more in need of aid than they themselves, and for whom their help was now actually being asked, gave these lepers a deeper satisfaction than any party arranged for them at their settlement last Christmas.

One of the great advantages of channelling aid through the United Nations rather than unilaterally from one nation, it is frequently said, is that it removes the stigma of dependence upon one powerful country. That is true. But it also limits the extent of appreciation. It is difficult for ordinary people to feel gratitude towards the United Nations or one of its specialist agencies. Is it desirable that gratitude should be felt? Emphatically it is. Help that is not appreciated may result in some material gain, but it makes no contribution to the vitally needed spirit of international courtesy. Taking things for granted is bad for the beneficiary: one has a right to hope that gratitude might be felt and expressed by a young developing nation, as much as with a young developing individual. When the field staff of U.N. Agencies have to press Ministries, month after month, to accept fellowships, equipment and international experts, all given gratis at international expense, it is surely time to reconsider the basis of such programmes. (At the conference in Berlin already referred to, the delegate of Pakistan said that his country preferred to accept assistance when there *were* strings attached: reciprocal assistance either in the form of an alliance or of other services rendered, was not only more naturally comprehensible—but more dignified.)

However, as things are today, benefactors themselves are also beggars, for the U.N. Agencies have to plead for their funds, and donor-States, whether under the Colombo Plan, U.N. Technical Assistance, Point-Four, or Colonial Development and Welfare, have to justify to public opinion at home the grants that they make. Unless there is an idealism to which they can appeal the money may not be forthcoming. (It is perhaps significant in this connection that U.N.I.C.E.F., whose technical *raison d'être* would sometimes seem to be superfluous in view of W.H.O.'s wider role, makes easily the most effective appeal: but even U.N.I.C.E.F. has had to employ Mr. Danny Kaye to further that appeal.)

Dare one say here that the notion of imperial trusteeship, *at its best*, provided at least a comprehensible motive for giving? I recall a summer evening four years ago, the Sunday evening before the Coronation, when I had gone into Kensington Gardens and crawled under barbed wire to find, and bring home to tea, two African soldiers from amongst the thousands of Commonwealth troops encamped there. Old gentlemen, some from their clubs, others up from the country, were converging on that camp, anxious to greet the sons and even grandsons of soldiers with whom they had fought years ago in far corners of the world, and in the street I was stopped four times by young men, asking how they too might find and show hospitality to these dark-skinned troops with whom they had recently served. When the ultimate verdict is given, perhaps we shall stand condemned not for the pride we showed in responsibility for other peoples—but for not taking *greater* pride and giving more whilst the opportunity was still ours. Be that as it may, in some of the unilateral assistance programmes, such as between Norway and India, in the field of fishing, there is discernible a more genuine concern in giving

on the one hand, a more real sense of indebtedness on the other, than in many of the larger international programmes of technical assistance.

There is an art in giving internationally—and this leads me to wonder whether it is really in finance that we today in 1957 can best make our contribution. It is fascinating to watch in S.E. Asia the contribution being made by the British Council in face of the gigantic gifts of the U.S. Information Service and Point-Four programme. We sustain grievous losses. At Rangoon University, in the Faculty of Philosophy, there is no single volume not published in the United States: the Siamese Navy, once so firmly wedded to Dartmouth, has gone over to the Anapolis system. But the Council's representative in Bangkok has laboured to speak fluent Thai: and the representative in Burma takes classes of young workers at 7 a.m., studying before they go to the office or the factory. The effort that is involved in both these instances is effort that is understood by the local people—and appreciated on that account. When massive grants are made by the British exchequer, only the Financial Secretary in the territory concerned can discern what part of the budget is represented by the Colonial Development and Welfare Fund from what has been raised by local revenue. But when John Wilson of the Society of the Blind goes out to Nigeria, himself sightless, that is something that can be understood—as we, in turn, can understand what Schweitzer's sacrifice has meant. When Major Seagrim walked out to give himself up to the Japanese, every Karen knew what it meant—and every Karen remembers. When the Liberator planes dropped food to African troops in the jungle in the S.E. Asia campaign of 1944, the Uganda troops called the parachutes 'Mother Kevani'—because forty years ago Sister Kevan, newly arrived from Ireland to find famine in the land, walked through their villages distributing food. When the octogenarian Lord Salter goes out to Iraq to write a report to end all reports, of a grasp and insight that astounds the international missions in the field: when one finds in Rangoon a boys' home marvellously organised and imbued with life and love by a Burmese lady, and learns that all this was inspired by one brief encounter with the late Alec Paterson, the great prison reformer, co-founder of Toc H, and friend of youth—then one is led to reflect on the nature of technical assistance, and to wonder whether financial aid—massive, impersonal, anonymous—is in fact the contribution that lies best in our power today. Like the Swiss, we have to concentrate on quality.

Suppose that the British Medical Association were to undertake to provide a dozen young doctors, for limited service in underdeveloped territories which simply cannot get them through their own resources. . . . Suppose that the National Union of Teachers, or the Association of Assistant Masters, were to undertake to find a dozen young teachers for limited service in 'difficult' territories like Somaliland and Sarawak. . . . Suppose that the National Union of Miners were to agree to allow Hungarians to work in the pits. . . . My belief is that we should recognise the limitations of *technical* assistance and of financial aid, and, *per contra*, be more alert to opportunities for other kinds of help: that we should study the factors which appeal to generosity and personal sacrifice, and which evoke gratitude and appreciation: and that we should concentrate on those forms of aid which stimulate self-help and which kindle in those assisted a willingness to help others in their turn.

And this is precisely the task of Fundamental Education also within these countries. The real battlefield is not, I feel, in the remote villages, but in the colleges and in what E. M. Forster calls the 'ivory laboratories' of the new universities overseas. Over 50 per cent of the population in S.E. Asia is under twenty: in Singapore the figure is 60 per cent. It is to the best of these, the privileged students and young intelligentsia, that we must appeal to regard the task of Fundamental Education as theirs—and not as the exclusive concern of the small, professionally employed cadres of welfare workers, trained by middle-aged expatriates like myself.

The job is too vast and too urgent to be left to the experts. It is not just a matter of continuing with the existing programmes of expanding schools and colleges in these countries. The gap between the technologically advanced countries and the under-developed territories is paralleled within these countries by the gulf between the educated and the illiterate—and under certain circumstances this, too, can widen.

A fortnight ago I was visiting village schools 250 miles up the Baram River in Sarawak. One encountered strange paradoxes there. Boys of seventeen could be found acting as headmasters, as medical dressers, as secretaries of co-operative societies—and carrying out these duties with a seriousness and responsibility that compelled one's admiration. Yet in Kuching, the capital, young men of twenty-four and twenty-five laboured under a sense of grievance if told that they were really getting a little too old to be still at school. Again, Sea Dayaks serving in the armed forces, in Malaya, as Jungle Rangers in operations against the bandits, or working in the oil fields of Brunei, have won golden opinions from their senior officers for their adaptability and initiative: they are the illiterate. But when one talks with the senior boys from the great, old-established secondary schools in the capital, it is to discover that many of them have never ventured fifteen miles outside the capital, and only yesterday a letter from the Director of Education tells me of how one day last week a young teacher just back from a two-year course in the United Kingdom had refused to be posted to a town four hours away by river steamer, and another Dayak teacher, just graduated from the training centre, was indignant at being requested by a Local Authority to go and help them by opening a new central school in their area. Education that might have been hoped to enlarge their horizon, to increase their sense of enterprise and their readiness to tackle challenging tasks, would seem to have had the opposite effect. It has emasculated their spirit of adventure.

Can it be said that more money, or more schools on the existing pattern, will of themselves solve this problem? In one Arab State, where the extension of medical services is as urgently needed as anywhere in the world, there are some 980 doctors: of these, some 620 are in the capital: and of these some 340 are to be found in the main street. Merely to increase the training facilities is not the answer. In that same State, if a road is blocked by filth, the tendency today is to approach W.H.O. for an international team of Environmental Sanitarians—when half a dozen youths with spades could do the work. Everywhere throughout the underdeveloped countries immense sacrifices are being demanded—and given—for the education of youth, from parents, from communities, from local authorities, from central governments, from overseas foundations and technical assistance programmes. Is it very trite to suggest that the future greatness of these countries will depend not on the sacrifices made by the nation for the education of youth, but on the sacrifices that educated youth are prepared to make for their nation?

When U.N.E.S.C.O. sent a survey team to Iraq some five years ago to select a pilot project in Fundamental Education, the decision was reached to establish a mission, of five international experts supported by ancillary local staff, at Dujailah. One of the survey team, Dr. Notbaart of the Netherlands, a man of immense experience in education in Indonesia, dissented from this view. His recommendation was to appeal to every young teacher-in-training from the province, to every student and senior scout, to spend the long summer vacation amongst the *fellahin* (peasants), billeted on their farms. At the end of the vacation every farmer at least would be literate. Four years later it was my unhappy task to wind up and close down that Dujailah project, a failure expensive in wasted money and wasted effort. Not only had Notbaart been right—he might have added that if his approach were adopted there would be the additional incalculable advantage that a group of young teachers and civil servants would emerge with first-hand personal experience

of the real practical problems confronting the development of their rural populations.

There are grounds for *not* despairing. The strange thing is that it is *not* difficult to inspire in young people a sense of the adventure in discovering their own country—and in discovering a feeling of common citizenship amongst those of different backgrounds. I dined in Singapore last week with a young Chinese doctor, an Indian electrical foreman and a Malay typist, who, with a group of like-minded friends spend every Sunday morning in what they call 'Operation Broomstick', cleaning up outside the new tenement buildings in Queenstown. '"Why are you sweeping up on my doorstep?" they ask me, said the Doctor, and I say, "Because you are not doing it yourself"—and then they laugh and join in with us. "We're going to start soon on 'Operation Flowerpot' and have flowers outside every tenement".' They have discovered that adventure lies, if not on their own threshold, at least on their neighbours'. And elsewhere in the world, particularly perhaps in India, where there is the inspiration of Gandhi's philosophy that 'Work is Prayer', students in their thousands are finding that to go out in teams to help in the slums and villages is an adventure in discovery. I spent last night here in Dublin with a Nigerian engineering student who looks back upon a month spent, stripped to the waist, labouring with other young West Africans on village reconstruction projects, as one of the most exciting experiences of his life. In the voluntary work camp movement there is a spirit abroad that might well be compared with the early years of the *Wandervögel*, the beginnings of the German youth movement of fifty years ago.

What Lewis Mumford, the great American sociologist, wrote in his *Faith for Living* in 1940 of conditions in the United States is no less true today of the situation in less developed territories;

> Meanwhile our young people are starving for lack of real tasks and vital opportunities. Many of them live like sleep-walkers, apparently in contact with their environment, but actually dead to anything but the blare of loudspeakers and the print of newspapers.
>
> But the young will care for their regional home if they have a part in creating it. Why should the young not have their first experience of public service on work that serves for local improvement? They should help clear the slums as well as study housing: they should help plant the forests as well as study conservation: it is our youngsters nearing the military age who should be toughened off in lumber camps, on fishing boats, behind the hay-wagon, and the threshing machine, on the road-gang and in the quarry.
>
> It should not need another war to effect this purposeful mobilisation of youth.

THE VASCULUM AND THE MICROTOME[1]

ADDRESS BY PROFESSOR D. A. WEBB

PRESIDENT OF THE ASSEMBLY OF CORRESPONDING SOCIETIES

I HAVE chosen for the title of my address today two instruments which are meant to be symbolic of two different approaches to the problems of biology. The vasculum stands for outdoor biology, field studies, natural history; the man who wears it is no doubt interested in many things besides taxonomy, but he is always in some measure concerned with taxonomy; and he is brought inevitably into fairly intimate contact with the complex diversity which characterises any biological community. This is the field of the amateur as well as of the professional. The microtome, on the other hand, stands for the analytical science of the laboratory, which, insulated from the complex flux of the community, pursues more recondite enquiries, often on a single plant or animal, or on a single part of a plant or animal; its studies belong to the realm of physiology or anatomy or cytology, but seldom taxonomy; and it is virtually the preserve of the professional today. Like all symbols these are in some respects imperfect. For one thing the vasculum pertains only to botany, and although I shall be thinking mainly of botany, much of what I have to say applies equally to zoology. (As some of you may know, I spent five years in zoological research before I became a botanist; I am, in fact, what is known in this country as a 'spoiled' zoologist.) I will ask you, therefore, to think of the vasculum as including, let us say, the tow-net. Secondly, they are to some extent old-fashioned: the vasculum has been largely replaced by that admirable invention the polythene bag; and in the realm of cytology, which is the laboratory science with which I shall be most concerned, the microtome has largely been replaced by the acetocarmine squash. But as we Irish are always behind the times, perhaps I may be allowed this touch of local colour.

In our sanguine moments we regard the two approaches to biology symbolised by the vasculum and the microtome as complementary: in our more depressed moments we regard them as competitive. But there is no doubt that they are different. There are some biologists who are able to divide their time between the laboratory and the field, and to switch their mind repeatedly from one set of problems to another, but such versatility is rare. It is versatility, not so much of talent, as of interest that is required, for most biologists feel themselves drawn especially to the problems and methods of the laboratory or of the field, and to some extent bored by the other. The direction which this interest will take is not easy to predict, as the wind of scientific curiosity bloweth where it listeth; I know this very well from my own personal history. It was the incredible richness and splendour of the life of the sea-shore that first determined me to take up biology as my career; my first five years of research, however, I spent wholly in the laboratory, happily surrounded by spectroscopes and burettes; then when I became a botanist, I passed, with a rapid transition, through physiological ecology to descriptive ecology, systematics and plant-geography. I started in the field, passed through the laboratory, and find myself now partly in the field, partly in the library. I cannot explain to myself the psychological compulsions behind the changes, but if I had to live my life again I would be quite happy to retread the same path. But my life, like that of most people, has to some extent been shaped by external circumstances; and in my own case these were perhaps somewhat unusual; in the ticketed, graded world of professional science of the present day few people find themselves in a

[1] Address delivered on Thursday, September 5, 1957, at the Dublin Meeting of the British Association.

position to change over from one subject to another. I think, therefore, that it is fair to say that, making allowance for some exceptions, there is a basic difference in temperament and psychology between field and laboratory biology, much more far-reaching than the difference between those who like fresh air and those who prefer the comforts of an indoor life. The field-worker's approach is essentially *extensive*: he is almost bound to take note of a number of organisms of different species, and he is brought up against the extreme complexity of the environment in which they live. He must have some taxonomic knowledge, even if his main interest is in behaviour or ecology, as taxonomy is the first preliminary step towards getting our bearings in the confusing welter of the organic world. He must, even if he concentrates his attention on one particular organism and perhaps one particular aspect of its life, pay some attention to its background; the complex community in which it lives. He proceeds by comparison rather than analysis; his conclusions are usually tentative and approximate and sometimes they must remain imprecise, but they apply with indisputable validity to the organism as it actually exists. To such a man the inexhaustible variety and diversity of organic nature is usually the centre of his interest in biology. At his worst he is a dilettante and a dabbler; at his best he has a synthetic grasp of the organism which is wider in its scope than any which formulae can provide.

In contrast to this the approach of the laboratory worker is usually *intensive*. By analysis and abstraction he isolates one problem of limited scope, and he brushes aside as a distraction and an irritant that rich diversity of nature which fascinates the field-worker. His results have precision and certainty, but the extent of the field over which they are valid is often uncertain. At his worst the laboratory worker is a spinner of hypotheses in a theoretical world which has little relation to the actual life of the organism; at his best he gives us a glimpse of the real foundations of life.

Where, in relation to this contrast, does the division between the amateur and professional biologist fall? When I originally offered the title of this address to the sectional committee they asked me to change it, to make it cover the contrast between the amateur and the professional rather than between the field- and laboratory-worker. But I was obstinate and refused to change, because the two contrasts, although they are related, are not the same, and I believe that the latter is the more significant. The amateur is, indeed, most likely to be a field-worker, and his interests are often mainly taxonomic. But this is partly for extrinsic, economic reasons. The eclipse, on the one hand, of a leisured upper-middle class with a sound education and the means to equip a tolerable laboratory at the bottom of the garden, and, on the other hand, the ever-growing complexity and expense of everyday laboratory equipment, has virtually put an end to the amateur laboratory-worker. There is, however, one part of this field where the amateur has, I believe, beaten an uncalled-for retreat—in abandoning the idea of possessing a microscope of his own. Microscopes are expensive, but they cost less today in terms of real wealth than they did in Victorian days, and many an amateur who regards a microscope as hopelessly beyond his means spends in fact more than its cost on his camera and accessories, not to mention his television set. One has only to run through the accounts in early numbers of the *Irish Naturalist* of the meetings of the Dublin Microscopical Club to realise what a contraction in the range of the amateur's contacts with botany and zoology follows from his failure to have access to even a fairly unpretentious microscope.

But while the laboratory-worker has always been mainly professional and is now completely so, there has always been a fair sprinkling of professionals among the ranks of field biologists, and the number has increased considerably in recent years, thanks largely to the establishment of ecology in a position of acknowledged respectability in university courses. There is nothing now to prevent a professor

from spending a large part of his research time in field-work, unless it is the refusal of his colleagues to believe that his life is anything but one long holiday. He will, however, thanks to his early training and his contacts with his colleagues, inevitably be to some extent in touch with the world of laboratory science; and he is therefore in a particularly favourable position to build bridges between the laboratory and the field. He has, indeed, received ample support from the best type of amateur who, though not a laboratory-worker, is prepared to do the reading and thinking necessary to understand something of what goes on in laboratories; but it is largely the efforts of the professional biologist whose interests lie mainly in the field that have produced the recent renaissance in natural history, or perhaps I should say the emergence of a new concept of natural history, at once critical and synthetic. I will leave till later a consideration of some recent achievements in this field.

Before I go further, however, I must mention in passing that there is one type of biologist who does not fit into my antithesis. This is the museum-worker. He may have recourse occasionally to a vasculum or occasionally to a microtome, but his outlook and methods are different from those of the laboratory- or of the field-worker. Like the former he is usually a professional, but like the latter he is inevitably concerned with taxonomy. At his best he is a sort of bulldozer, clearing a path of ordered knowledge through the vast jungle of nature: at his worst he is a mandarin, exaggerating and glorifying in the more recondite and technical aspects of nomenclatural and taxonomic lore. He forms really the third point of a triangle, and my only justification for not giving him more space is that numerically he comes a long way behind the field- or the laboratory-worker.

In an ideal world these different types of biologist would prove complementary (and indeed for that matter also complimentary) to each other; each would provide at once a stimulus and a critique for the others; each, while retaining his own methods, would respect the methods of the others and learn from their results, and there would be no disputes as to what were the 'true' methods of biology. But we do not live in an ideal world, and although there is plenty of co-operation of this sort between the field- and the laboratory-worker, there is also rivalry, mutual disparagement and misunderstanding. Let us examine the gloomy side first.

It is only human to believe that the work which you are doing is more interesting than the next man's; you would presumably not be doing it otherwise. This does no harm so long as you recognise your attitude as subjective. But to objectify and generalise it, and to suggest that anyone who is not working in the same field as yourself is wasting his time is a very different matter. Again, if you feel that your subject or angle of approach does not get all the recognition that it deserves, it does no harm to give it some publicity, even if you seem to be blowing your own trumpet at the same time. But it is not necessary, to achieve this, to depreciate and misrepresent the other branches of biology, in which you are not interested. And I'm afraid that there are still too many biologists who go around doing just this: they are, of course, a minority, but a noisy and troublesome one, and sometimes they get the ear of the majority. We are all familiar with the physicist who looks on the student of classics as a futile word-spinner, or the historian who regards the chemist as a dangerous barbarian. Such people are at once a symptom and a cause of the disintegration of culture which so plagues us today, and I hope that there are few in my audience who would defend them. But intolerance of this kind is also to be found within the realm of science, and even within the confines of one of its branches, and it is my chief aim today to suggest that the depreciation by the field biologist of the work of the biochemist, or by the geneticist of the work of the taxonomist, is based on prejudice and ignorance. We would all agree that at a given moment some branches of science are more likely to provide spectacular results than others, and if my only aim in life was to become President of the Royal Society I should certainly regard biochemistry, physics or genetics as a better bet

than palaeontology or ecology. On the other hand, if I wanted above all to be certain of leaving a respectably-sized brick to be built into the general fabric of scientific knowledge, I would be inclined to give the preference the other way. The difference in temperament between the man who is determined to prove himself a genius, and the man who knows he isn't a genius but wants to use his talents to the best advantage, is, no doubt, another factor in generating the tensions which I am discussing. But it only needs a very little reflection to see that the progress of science would be equally impossible if there were no geniuses at all, or if every working scientist was a would-be genius.

I have already suggested that there is an inevitable tension among biologists, between those who are drawn to the subject by the fascination which the diversity of nature has for them, and those who are distressed by this diversity and struggle to reduce it to a pattern or a formula. I think it was Broad who said that if the universe were completely homogeneous and simple, or completely heterogeneous and complex, it would be in either case impossible to say anything about it. The possibility of science arises from the fact that the universe combines great diversity with some degree of order. So also with the organic world: if we can find no laws, formulae or generalisations to apply to it, we can but play with it as a child plays with a kaleidoscope; we can contemplate it with wonder and affection, but we can hardly call our attitude scientific. It is no use naming organisms unless you can determine the principles on which you are going to classify them; it is no use determining their geographical distribution unless you can deduce from it some factors influencing distribution which apply to more than one species; it is no use speculating about ecology unless you know a little physiology. And in every case the search for the law, the principle, the generalisation, the device, whatever it is, which enables us to tie up our brute facts into bundles and to think about a number of them at the same time, can only be achieved by abstraction, by ignoring details even if you know that they are relevant, and by isolating the organism to some extent from its environment. Unorganised natural history is a pleasant recreation, but it is scarcely science.

On the other hand I cannot regard as scientific the attitude of the more radically-minded laboratory-worker with a one-track mind who is convinced that when he has discovered something about the respiratory enzymes or the genetics of one organism that it must apply to all, and who is always promising a millennium just round the corner, when one more discovery in the realm of physical chemistry (it is coiled protein chains today; fifteen years ago it was liquid crystals, of which we hear little now) will finally solve the problem of life and render all pre-millennial biology for ever out of date. This brash outlook is fortunately not very common, but the laboratory worker, even the humble-minded one, has constantly got to be reminded of the process of abstraction which has, quite rightly, been interposed between the organism living its daily life and the experiment in the laboratory. When we try to use the results which the experiment has taught us in reconsidering the life of the organism, we must remember that the complexity which has been removed must now be put back again. The geneticist must think in terms of genes, but he must remember that the organism lives its life, not in terms of genes, but of their expression. The physiologist may find that the only theoretical treatment of use to him is based on ionic interaction in infinitely dilute solutions, but he has to remember, in applying his findings, that sea-water is far from dilute.

The path that leads to truth is usually a zig-zag one; it must dart to and fro between simplicity and complexity, between reality and abstraction. I forget who it was who gave as a working motto for the scientist, 'Seek simplicity and distrust it', but it sums up well what I have been trying to say. It is not given to all of us to integrate this dual outlook in a single life: some of us are born seekers and others born distrusters. But this does not matter so long as we are prepared to play ball

with our opposite number. Much of what I have been saying may have seemed commonplace to some of you, and perhaps you think that I am battering at an open door. It is, indeed, open, but not everyone will walk through it; there are, alike in field clubs, in museums, in universities and in research institutes, pockets of resistance still to be reduced. And by resistance I mean the failure to recognise the manifold nature of scientific method: the assumption that one's own method of study is the only, or at least the surest path to enlightenment.

Let us look at it first of all from the point of view of the amateur. His faults are always more pardonable than those of the professional, since he has not had the wide education in formal biology which should help him towards a sense of proportion and a synoptic view. But faults, even if pardonable, remain faults, and there is no doubt that the reluctance of many amateur field-workers to use a microscope or any other technique unfamiliar to them, or to do enough reading to understand the implications of chromosome counts, compares unfavourably with the immense appetite for relevant information of all kinds which their predecessors showed two generations ago. One of the by-products of this century's cult of the open-air life is that a certain prestige attaches in some people's minds to outdoor work, especially if carried out under conditions of discomfort; and intellectual laziness is easily covered up by casting a sort of moral slur on the scientist who works in the shelter of a laboratory or, worst of all, sits in a comfortable chair thinking. Nor does a realisation of the importance of knowing your organism as a whole justify you in belittling the importance of what the man who works by analysis may have to tell you about its parts. I was rather shocked to hear, in a discussion in this Section last year on the health of local scientific societies, a speaker who was urging that lecturers should at all costs avoid specialisation and analysis, say that he was 'sick of the sound of plant biochemistry'. Now in plant biochemistry, as in all subjects, there can be good or bad, apposite or inapposite lectures; but it is foolish to suppose that any botanist who wishes to broaden or deepen his understanding of pigmentation in plants, of their tastes and odours, of their poisonous principles, of the factors regulating the growth and setting of the fruit, and of a dozen other topics in their general biology, should reject an opportunity for learning something of plant biochemistry. There is, indeed, a danger of not seeing the wood for the trees, but there is also the danger of forgetting that without trees there is no wood.

Again, I am afraid that there are still some field-workers, and for that matter museum-workers too, who regard the cytologist as a busybody who comes blundering into their field without a message that is of any use to them. They have some excuse for this in that most of the popular accounts of chromosomes and their doings are more concerned to describe the new world that cytology opens up than to set out clearly the light which it casts on the old world of taxonomy. We can excuse the amateur for hesitating before plunging into the world of ecogenodemes and hologamodemes; but it is a pity that he does not always realise that cytological information can sometimes provide him, within his own familiar terms of reference, with a short-cut to conclusions which are more firmly based than those that he could hope to reach without it. Floristic literature would be less cluttered up with putative hybrids than it is if their authors were prepared to take two steps which are usually not very difficult—to ascertain the chromosome numbers of the supposed parents, and to examine under a microscope the pollen of the supposed hybrid.

Now let us turn to the shortcomings of the professional and of the laboratory-worker. Here I must be more severe, for from him to whom much is given much shall be demanded.

His commonest fault is perfectionism. This is, unfortunately, rather closely linked psychologically with those qualities which go to make a first-rate critical intellect, but it is none the less a failing. The professional sits down and computes

how, in order to do a certain job properly, four men, supported by handsome grants, are needed for five years; he sees no hope of these conditions being fulfilled, so he gives it up. It is very good for him that now and then the amateur comes along and does the job unaided in two years in a rough-and-ready way. It is a striking fact that for very many years all floras for field use have been written by amateurs; the professional simply cannot bear to leave out all the irrelevant information he knows, and his book becomes too big for the pocket. Certainly I was the veriest amateur in botany when I first planned my *Irish Flora*, and only a courage based on ignorance enabled me to write it. If I were to start from scratch today I am sure that I would bog down sadly.

But there is a fault worse than perfectionism which besets some professional laboratory-workers: it is the arrogant disdain for what he considers old-fashioned branches of biology which continue to muddle along instead of enlisting under his banner. The professionals in the so-called old-fashioned branches can look after themselves all right, but I wonder do these revolutionaries realise the price they are asking us to pay in totally annihilating amateur science. For that is what it comes to. The newer branches of biology, and, I fancy, of most sciences, are closed to the amateur, since they demand well-equipped laboratories; and even the professional field-worker, though he should, as I have already suggested, be interested in their results, cannot afford the time to perfect himself in their techniques. Enthusiasm is a heart-warming quality, but when the enthusiasm leads to belief that truth can be approached only along one channel, then one has to remind oneself that a cool head is needed as well as a warm heart, and one begins to think of St. Paul's words, trite though they be: 'If the whole body were an eye, where were the hearing? If the whole body were hearing, where were the smelling?'

I have been provoked to these remarks partly by the reading of Professor Darlington's *Chromosome Botany*. Bouquets should precede rotten eggs, and I hope I will be believed when I say that for about seven-eighths of the book I have a profound admiration; it gathers together from a very scattered literature a large number of interesting facts, and it presents them in a small compass with clarity and, indeed, brilliance. In fact, the success of this major part of the book is so well assured and so well deserved that it makes one wonder why the rest, which is a feverish exaggeration of the merits of cytogenetics, and a depreciation, by caricature and misrepresentation, of the claim of taxonomy to be considered a reputable science—why this other part was ever written. It is one thing for the author to say that we can demonstrate a certain evolutionary process 'with Euclidean rigour' when in fact the argument, very plausible though it is, involves induction, analogy and speculation. Euclid has turned in his grave before now, and will doubtless be required to turn again; my only comment is that good wine needs no bush, and if an argument is really rigorous the rigour is plain for all to see. But it is more serious when he assures us that cytogenetics is not to supplement ordinary taxonomy; it is going to replace it altogether. Here is what he says (pp. 33–4):

> Can we add the chromosomes as an appendix to the otherwise sound work of museum classification? The answer is that we cannot. We must make clear at once that the two systems are unavoidably in conflict. There can be no compromise between them. Either we can follow a scholastic system . . . or we can follow an experimental system.

Now I suppose it is just possible that a man might seriously believe that and try to act on it. But whoever acts on it it is not Professor Darlington. For consider its implications. We can never refer to plants by their Latin names: only by their chromosome maps; and we will only know these in the case of plants grown in experimental gardens from individuals that have been examined cytologically. We can make no statement whatsoever about a wild plant that has not been under the microscope, as we have no niche in which to classify it. I need not go on; you can

see what an Alice-in-Wonderland world we are entering. But Professor Darlington does not enter it; on every page of the book he refers to species, genera and families by their Latin names, just like any unregenerate taxonomist who has not seen the light.

It may be said that I am making too much of what is only a *jeu d'esprit*; that every science needs its *enfant terrible*; and that it is good for everybody for a cat to be put among the pigeons now and then. All very true, but the theme is too recurrent in the author's works for us not to suspect that he may really mean it, and the Chair of Botany at Oxford gives one, whether one wants it or not, a position in which one is bound to be taken seriously. But for these views to be taken seriously would be disastrous, and not least for the future of cytogenetics. Propaganda of this kind plays straight into the hands of the over-conservative taxonomist; it leads him to believe that cytogeneticists are bullies and vandals as well as revolutionaries and gives him a good excuse to have nothing to do with them. It is Colonel Blimp who makes most converts to Communism, and vice versa.

Professor Darlington has two interesting epigraphs at the beginning of his book: one from Gilbert White and the other from Hooker. The first declares that botany, if restricted only to taxonomy, 'amuses the fancy and exercises the memory without improving the mind or advancing any real knowledge', and that physiology and agriculture should be studied concurrently with taxonomy. The second laments that foolish pedantry in taxonomy often makes students desert it for physiology, which they cannot effectively pursue if they know no taxonomy. With both of these I am in the fullest agreement, and if the argument had been developed on these lines I should have had no quarrel with it at all.

Well, I have been grousing far too long; let us end on a more cheerful note. There is little doubt that, despite the exceptions which I have been worrying over, the variety and effectiveness of the contacts between the field and the laboratory have been greater over the past twenty years than at any time since mid-Victorian days. In botany, I believe that the publication in 1939 of Tansley's *The British Islands and their Vegetation* was as important as any other single cause in bringing about this *rapprochement*, and there is no doubt that the appearance thirteen years later of Clapham, Tutin and Warburg's *Flora* has supplied the movement with an injection of fresh vigour. I will mention only two of the most obvious results of this regime of collaboration. The first is the series of *New Naturalist* books. These have, of course, varied greatly in quality: a few have been dull, a few trifling, and a few inaccurate. But the majority of them have succeeded well in what they set out to do, and they present a combination which has seldom been equalled of experienced field observation, sound taxonomy free from insular limitations, and up-to-date knowledge of relevant experimental work. They have been good for their authors as well as for their readers; for the professional authors have often had to seek advice from the amateurs on local details, and the amateur authors have had to read more widely and more deeply than they would otherwise have been likely to do. They have succeeded positively in the knowledge that they have presented, but even more far-reaching, perhaps, will be a more negative success, in that they have turned a spotlight on the enormous areas of ignorance that must be overcome before we can present the whole of the natural history of even as well-worked and as poor an area, biologically speaking, as the British Isles in the scientific manner whose possibilities are indicated by these studies.

The second example is one in which I am intimately concerned: the scheme of distribution-maps for vascular plants put in hand three years ago by the Botanical Society of the British Isles. Until the atlas is published one cannot fully assess the value of this work, but it is quite clear that it could not have been performed by amateurs without the help of professionals, and equally truly vice-versa. Most of the data are being collected in the field, but much work has to be done in libraries

and museums to supplement this, and for the critical taxonomy that is so important if the work is to have any real value, we are ultimately dependent to some extent on the laboratory. I think it is true to say that both amateur and professional have received refreshment and enlightenment from the contacts which this work has imposed upon them.

One might discuss other fields of collaboration, such as that which has given such a serious bent to the extraordinary enthusiasm for bird-watching which the last few years have seen, but my time is up. May I, however, before I conclude, release among the pigeons of this Section a very small kitten by enquiring how its activities are affected by the theme which I have been discussing?

This Section is primarily for amateurs. It is good that representatives of local scientific societies should be able to get together and discuss their common interests. It is excellent that somebody in the British Association should sponsor, as this Section does, talks by budding scientists still at school. But the primary aim of the British Association is to bring the professional and the amateur together, and I wonder whether this Section, in providing for itself so full a programme, is not hindering this purpose. Ought you to be here listening to me; ought you not rather to be at Section C or D or H or K? We can't all be interested in all the sciences, and a programme for this Section is inevitably a bit diffuse. Should it not, therefore, be kept fairly short, on the understanding that most of us here are primarily interested in one or more of the sciences discussed elsewhere, and want to learn more about them?

I am afraid that this address, when you really boil down its message, is very trite. On the one hand this is excellent and on the other hand we must not forget that. Let us promote tolerance and harmony, and walk hand-in-hand into the golden future. In fact, I've been rather like a governess or nanny, in my scoldings as well as my aspirations: 'Come now, Master John, you've read that comic through three times; isn't it time you read something new.' 'Steady there, Master Cyril, just because you're clever that's no reason to be so wild.' And so on. As for the aspirations, I can only say that sometimes truth is trite. And as for the scolding, I don't suppose it will have any more effect than that of most nannies. But I trust that at least, if I have given you no pearls of novel wisdom to take away, I will have stuck out my neck enough to promote a stimulating discussion.

EDUCATION FOR DEVELOPMENT[1]

by

SIR SYDNEY CAINE, K.C.M.G.

ONE MIGHT sometimes think that economic and social development is a thing that has only commenced in the very last decade or so. That is certainly not true. What has happened is that there has been a good deal more talk about it and, somewhat more usefully, more conscious thought about the things that are necessary to bring it about. The talk and the study tend to be concentrated on the problems of what are called the under-developed countries. That can be misleading because there is no country in the world which is yet as fully developed as it could be, still less as fully developed as its inhabitants would like it to be. Indeed, if we look at what is actually happening and put aside the stock speeches of politicians and publicists, a great deal more capital and a great deal more effort are going into new developments in what are called the developed countries than in the under-developed.

It is, however, primarily about the under-developed countries that I intend to talk, and especially about the role to be played in the business of development by education. But before doing that I must delve a little into economics. First, what do we mean by 'development'? What is the difference between the developed and the under-developed countries? It is by no means a difference between countries whose natural resources have long been subject to human exploitation and those where highly organised human activity is very recent. True, there is much virgin soil in parts of Africa, in South America and in South-East Asia; but other and more populous under-developed countries like India or Egypt reckon the history of their settled agriculture and highly organised economies in millennia, while some highly developed countries, like the U.S.A. and Canada, reckon their history only in centuries. The real difference lies not in length of economic history but in the magnitude of current incomes and current capital equipment. Broadly we may say that the under-developed countries are the poorer countries of the world and the developed are the richer.

If somebody asks what is meant by poor and rich there is no easy answer which is both precise and generally acceptable. Whether we assess riches on the basis of total output of goods and services, or total consumption or the total of accumulated capital, precise measurement and valuation present acute difficulties. Moreover, many writers have urged that account must be taken not only of the total volume of income and consumption but of the way it is distributed or of the extent to which there is freedom of choice in the way incomes are spent.

Nonetheless, whatever fuzziness there may be in the precise definition there is not much dispute about which side of the line most countries fall. It is not necessary to quantify it exactly to be able to say confidently that India or China or Nigeria is a poorer and therefore, in current language, a less developed country than the United States or Britain or Australia. And, similarly, it is fairly easy to be sure that particular policies will be developmental, that is will increase wealth, without necessarily being able to say precisely how much extra wealth they will create.

At the bottom, therefore, of the business of development is the business of creating wealth. And leaving aside the complications and sophistications of modern economics the creation of wealth depends on the application to a country's basic natural resources of human skills and human labours assisted by capital equipment,

[1] Public lecture delivered in the library of the Royal Dublin Society on Monday, September 9, 1957, at the Dublin Meeting of the British Association.

in turn the product of human effort. Of natural resources I need say no more than to emphasise how useless they are without human skill and labour. It is easy today to envy the United States their natural wealth, but consider for how many millennia that wealth lay unused and how recently the right kind of human skill has converted it from latent into actual wealth. Nor ought I here to say much of the role of capital except again to emphasise its dependence on the human endeavour and the human abstinence which is needed to bring it into existence.

Let me quote one or two examples. If you fly along the northern coast of Brazil you pass over hundreds of miles of uninterrupted steamy forest. Suddenly the scene changes to an ordered pattern of rice- and cane-fields, canals and roads. Then after a while the pattern vanishes and again there is only forest. That ordered pattern is the area of Guiana and the reason why it has been developed and the neighbouring lands have not is simply that the Dutch went and settled there and applied to the coastal swamps their special skills in drainage. On the industrial side I was once closely concerned with industrial development policy in the British Colonial Empire and I was struck by the fact that the only two dependencies which showed any real growth of manufacturing were Hong Kong and Palestine as it then was. Neither had any of the things *prima facie* theorists lay down as necessary for the growth of industry. They had no raw materials, no great local sources of power, no large protected markets. What they did have was a variety of skills and enterprise, brought in by immigrant Chinese in the one case and immigrant Jews in the other, and made use of under an efficient administration. Again I thought I saw something similar in Armenia, where I spent some time last month. There, too, there has been an immigration, of Armenians coming from other parts of Russia, from the Near East and from Europe with special skills and abilities, and there, too, a considerable urban and industrial development is going on. Erevan, the capital of Armenia, is not yet a Tel Aviv or a Hong Kong, but it has grown in a generation from a small town of 30,000 people to a city of half a million and contains many new factories based, so far as I could see, on the natural abilities of the population rather than on the natural resources of the land.

My subject, then, is the spreading of the knowledge and the skill which are basic to the whole wealth-creating business. One thinks first of the technical skills which are needed in development; the technical agricultural skill which will make two blades of grass—or often twenty blades of grass—grow where one grew before; the technical mining skill which will extract wealth from the bowels of the earth; and the techniques of industry which will bring mechanical power and modern manufactured products to wider and wider populations. These technological fields of study are already vast and ever growing. I no longer know into how many branches engineering is divided, or how many *-ologies* the fully qualified agriculturalist needs to master; and it is anybody's guess how many more will be added before this Association meets again.

If I pass over those technical and scientific studies very briefly it is partly because any attempt to particularise would lead me into a discourse far longer than I have time for or you have patience to listen to. The growth and branching out of scientific studies is well illustrated in the growth of the sections and divisions of the British Association itself. Correspondingly the spreading of this knowledge is an enormous and ever-growing task.

It is the greater because merely technical knowledge is by no means enough. First in support of it must be more fundamental scientific knowledge, knowledge of the basic physics and chemistry and biology. Less obvious, and especially apt to be forgotten in the countries of the West, is the need for the habit of mind which accepts and applies technology, which combines the knowledge gained from books and laboratory experiments with the willingness to engage in hard and dirty labour. In too many countries ostensibly avid for development, the tradition lingers that

the man of book learning does not soil his hands. In Malaya I have been told of students in the College of Agriculture, who, when first asked to undertake practical farm work, have offered to hire coolies to do it for them if the College was too poor to pay the wages. A story is told of the Emperor of Abyssinia who was attending a demonstration of farm tractors and learned that the oily-handed mechanic cleaning one of the engines was a university graduate. 'Ah', he said, 'it is that young man we need to demonstrate, not the tractor.'

Nor does the need for wide education by any means stop with the need to give the technical expert himself a sufficiently broad basis. The technologist needs also the support of more general education in two senses. First, although the creation of more wealth is, as I have said, at the basis of the idea of development, it is not the end of it. Other things are needed for a full and healthy social and economic development. A country in the purely physical sense of an area of land can be developed by the establishment in it of mineral or agricultural production under the control of non-resident technicians and managers, using local or specially imported unskilled labour. But if the country in the sense of the people who are its inhabitants is to be developed, that means raising them to a higher level of social organisation and economic capacity; and such a raising of the social level of the population can follow only from a higher level of education.

Let us look at some of the specific matters which point the need for more general education. Once economic enterprises of any size begin to emerge it becomes necessary, as anybody concerned with large industrial enterprises knows, to employ quite a lot of people on office jobs which, however unnecessary they may look to the engineer or the chemist, are quite essential for purpose of financial control, personnel management, etc. Thinking again of the examples I quoted a few minutes ago, in all of them there was present not only technical skill but organising skill which is itself based on education.

Secondly, economic developments do not take place in isolation. As more wealth is produced, new problems of its distribution and utilisation arise. As new enterprises grow in size, new economic problems of urban development, of relations between management and labour, of unemployment and social security, emerge; and to deal with those it is necessary to have education in the economic and social spheres as well as in natural science and technology. Thirdly, and perhaps most important of all, in many cases the problem of economic improvement is not fundamentally one of technology but of sociology. Over and over again the would-be developer comes up against a situation in which there is no doubt that a major technological change would substantially improve economic output, but it is not adopted because of sociological obstacles. For instance, when I was in charge of a team doing an economic survey of Ceylon for the International Bank our agricultural experts came to the conclusion that the rice production of Ceylon could be increased substantially by major new technical developments of irrigation and opening up of unused land, but it could also be increased much more substantially by the adoption by existing rice cultivators of better methods already completely proved elsewhere. What was needed for the irrigation and land development was considerable capital investment; what was needed for the improvement of existing methods was propaganda and persuasion, but propaganda of a complex kind because the existing technique of rice growing was bound up with the whole way of life of villages and affected family relationships, inheritance and even religion. It was therefore bound to be a long job and a job for the sociologists as much as for the agricultural technician.

The second broad aspect of the need for general education is that it is not merely necessary that what might be called the directors or operators of development must be trained in many matters other than technology; it is also necessary that the general public with whom they are dealing should be sufficiently well and broadly

educated. In the type of case of which I have just been speaking where improved technical achievement depends on the willingness of people to accept new methods, some basis of mass education is essential. And the more complicated the new methods which it is desired to introduce, the more basic education is required. As agricultural operations become more complicated, as the farmer has to take account of, say, the operations of a large irrigation undertaking, has to be aware of movements of prices in distant markets, and has to be able to receive and understand new information about cultivation or fertilisation or other production techniques, it becomes more and more necessary that he should not only be able to read and write, but should have some general and scientific education. It has never been true that a literate farmer is automatically a good one, but it is more and more tending to be true that an illiterate farmer is a bad one.

This need for a sufficient level of general education arises also, of course, in all industrial or other advanced technological operations. In most under-developed countries the shortage of mechanics and skilled craftsmen is as much an obstacle to rapid economic development as the shortage of professional engineers. I have seen that in the process of education itself. In Malaya, the level of craftsmanship and mechanical skill is a good deal higher than in many under-developed countries, but one of the greatest problems of the scientific departments of the University has been that of finding laboratory technicians and assistants. The Professor of Zoology, instead of having experienced assistants who could find and prepare for him the specimens needed for dissection in student classes, found at first that he had to do nearly all that for himself, or get expensive and highly trained university lecturers to do it, until after a process of years local people were trained up. The University had succeeded in getting one trained glass-blower, but so far as we knew he was the only man in the country with the necessary skill to produce the various queer-shaped bits of glass that the chemists and physicists were always demanding, and the Professor of Chemistry used to say that he dare not think what would happen if this man should die or decide to seek his fortune elsewhere.

What I have been trying to emphasise so far is that it is a mistake to think that what is needed is simply more technology; that if only enough engineers and architects and chemists can be quickly produced, the problem of economic development will be solved. All experience shows that technology is not enough. There are no simple formulae which can be handed over to the scientists and on which they can then create a new economic society; there is no equivalent to the Philosopher's Stone which can create more wealth without a great deal of background. General education is needed in three different senses; education of technicians not merely in technology; education in the social as well as the natural sciences; and education of the mass of the population as well as of a technical *élite*.

Thus education for development becomes very little different from education—period, to use an Americanism. The problems of education for development are in substance the problems of education in under-developed countries, that is in poor countries. I want therefore to turn to some of the special problems of education in such countries. First and most obvious is the fact that because they are poor they find it hard to pay for the education they want. Modern technical education is not cheap and when you are starting more or less from scratch and are trying in a few years to build up the schools, university laboratories, libraries and so on which more developed countries have acquired over generations, the cost is frightening. In the university colleges of British Africa running costs are well over £1,000 per annum per student. In countries with an average income per head still less than £50 per annum, it is obvious that they cannot maintain a ratio of university students to total population anything like that prevailing today in the United Kingdom. In Singapore, one of the richest of Asian countries, education in all forms already absorbs £5 per annum per head of population. In its larger but

much poorer neighbour, Indonesia, average total income is still probably not more than £25 per annum. We are faced with the paradox that only highly developed countries can afford general education in its modern form and only widespread education can produce high-level development. It is a new form of the hen and the egg problem.

Let me turn now to more specific problems. First there is the vast complication and obstacle to the educational process created by diversity of languages. In many under-developed countries, and not only in colonial or former colonial territories, we find the great mass of the people speaking a local language or more commonly a wide variety of local languages; and a small upper class speaking English or French or another of the languages of Western Europe, and that exotic language has come to be the main medium of intellectual activity. Within the Soviet Union the same relationship tends to emerge between Russian and various local languages.

The local languages are, in the short-run at least, generally inadequate vehicles for modern education, but at the same time they are the only vehicles through which the mass of the people can be reached. In the extreme cases, say in Tropical Africa, there is virtually no literature in the local languages; in others, with a long previous history of cultural activity, the current production of literature may be small; even where there is a large current literary activity there may be comparatively little publication in scientific, economic and social matters. Modern science and philosophy, modern social and economic discussions are expressed primarily in the languages of a few developed countries, and some knowledge and use of those languages by the more highly educated individuals may be essential for developmental operations. There is thus a gulf between higher education, making great use of languages foreign to the mass of the people, and mass education, necessarily conducted in the local vernaculars.

In the larger units the solution no doubt lies in developing higher education also in the local languages, but it is very hard to do that at the speed which current impatience demands. The real problem appears in practical form when educators have to organise the supply of text-books. In the lower levels of education there is very frequently a great shortage of suitable reading matter of the kind we take for granted in English schools, and the production of suitable text-books—elementary geography, history, and so on—takes quite a time. The more nearly one gets to the higher levels of education the more difficult the problem becomes, because of course the more numerous and more complicated the text-books become. At the highest level of all, of course, at the university and postgraduate level, learning is dependent on access to the flow of current thinking and research in learned journals, and the task of translating those into innumerable languages is so formidable as to be virtually impossible. Just about a year ago I saw an exhibition organised by the Indonesian Government of books published in that country. They were very largely translations, but still pathetically few and elementary. I could not but feel that they were starting almost as much from scratch in producing a printed literature as William Caxton was in England 500 years ago.

Great as is the real problem of bridging this language gulf, it is, I fear, further complicated by the emotional aspects of language. The use of a particular language is everywhere a sign and a symbol of nationalist feeling, and in practically every country which has passed out of foreign control into a state of independence a real and very popular effort to substitute the local for the foreign language at all levels has been made. In India and Ceylon, in principle if not in practice, the intention is to replace English by Hindi and Sinhalese respectively, with such other additions as internal politics require. In Indonesia the use of Dutch is officially barred throughout the educational system, although at the university level the familiarity of both teachers and students with Dutch and the fact that the bulk of the university's library is in Dutch results in a substantial if irregular use of the Dutch language. This

movement towards the substitution of a local for a foreign language raises not infrequently acute internal problems of rivalry between different languages, since there may, as in India or Nigeria, be scores of local languages and dialects. Even where, as in Malaya, the dispute has so far been conducted in peaceful if somewhat vigorous argument, the solutions envisaged are frightening from the point of view of the educationalist since there are three widely used languages besides English—Malay, Chinese and Tamil—and the local Governments are aiming at making the whole school population bi-lingual if not tri-lingual.

Such multi-lingual education at nearly all levels only intensifies the practical or economic problem of education in such conditions. It is unfortunate that at a time when rapid progress in education is so much needed, teachers and scholars alike should be handicapped by having to spend time learning two or three very diverse languages instead of one, and finding their education delayed at all stages by lack of text-books and translations. One is almost forced to wish that more of the under-developed countries of the world were in the position of, say, the British West Indies, where the institution of slavery swept away linguistic as well as many other problems by wiping the slate clean and enabling something more simple to be built up.

That leads on to another of the major difficulties, the general shortage of personnel. I have already given some indication of it in discussing the need and the costs of general education as a background for developmental activity, because that is only another way of saying that there are not at present anything like enough educated people to do the jobs required and more education is needed to produce them. What I am concerned with at this point is the shortage of people to do the educating. Precisely because of the shortage of highly trained men and women, it is hard to find enough of them to go into the higher levels of the teaching profession. I am thinking here especially of the country duly emerging to national status from former colonial dependency. In such countries the demand for the better educated local people is insatiable. Government posts previously held by nationals of the colonial power are vacated and have to be filled by local people. In ordinary business, commercial concerns with an eye to the political climate may equally be seeking to increase their locally domiciled personnel in the higher levels of management. These demands pull away the potential teachers from the university and the schools.

At the same time emotionalism complicates this picture also. If there is a local university or other institution of higher education which has in the past been principally staffed by non-nationals, it is inevitable that local citizens include it among the natural consequences of independence that those expatriates should be replaced by local people, following the example of government. The institutions of higher education thus come under pressure of a kind which is certainly not good for education. Very often precisely the people who are most clamorous for more education are most anxious that it should be in the hands of local people—that is, that the least use should be made of outside assistance.

I will mention one other of the special facets of this situation, the great impatience of the under-developed countries, or at least of their governments and publicists. It is taken for granted that if only the right things are done, real incomes can rise and real wealth grow unprecedently quickly until everybody is as rich as that universally envied race, the Americans. Maybe it is due to a rather excessive faith in modern technology, maybe to the power of modern communications in making apparent the contrast between rich countries and poor. Anyway, the impatience is there and it has its effect on education as on other things. It is by no means all bad because impatience does provide a driving force, but two obvious dangers emerge. First the quality of education may be diluted in order to attain quantity; secondly, aiming at quantity may so overload the teachers that they fail to do much

good to anybody. In higher education, the first danger shows itself in the assumption that provided a student ends up with something called a degree its content and standard do not matter, and in the multiplication of inadequately equipped and inadequately staffed universities. The second shows itself in the admission to universities of large numbers of ill-prepared students whose instruction in the elementary matters they should have learned at school occupies the energies of the most highly qualified teachers. The problem is by no means unknown in developed countries, and is at present being specially studied in Australia; but the extreme example known to me of the combination of a liberal admissions policy with a real effort to maintain proper degree standard emerges from figures appearing in a recent report by the head of the University of Indonesia. In the year in question the Faculty of Engineering had 2,000 registered students; 1,300 of them were in the first year, a dozen or so in the fifth or final year, and precisely one graduated.

I have said enough to indicate that the job of education for development is an enormous one and a long one. It follows also from many of the considerations I have mentioned that it is a task which by its very nature must fall mainly upon the under-developed countries themselves. Only they can provide the mass of schools, the multitudes of teachers and the volumes of vernacular literature needed for mass education. That responsibility is amply recognised both by Governments and by private persons in the under-developed countries. In a country like Malaya the thirst for education is everywhere apparent. Expenditure upon it has grown very rapidly since the war; educational events attract full, almost excessive, newspaper attention; and private people at all income levels undertake real sacrifices to keep their children at school. This thirst is world-wide. When I was in Armenia I was told there that half the population were undergoing some kind of education—in schools, in the local university, in institutes of adult education, etc. The percentage may be exaggerated, but ample evidence was visible—literally concrete evidence—of many newly built schools and institutions, while bookstalls in Erevan were doing a large trade in elementary school books. The general thirst is apparent at the level of higher education in the ever-growing flow of students overseas. In spite of the growth of local colleges and universities, more and more students from Asia and Africa are seeking special training outside their own countries. Most of them go to the United Kingdom, to other Western European countries, to the U.S.A. and Canada or, in the case of the Communist group, to Russia or China; but many go also to what are normally thought of as under-developed countries; so Africans may go to India or Indonesians to Egypt. Today the U.K. has 30,000 students from overseas at institutions of higher education, not all but a great majority from under-developed countries. Many are supported by scholarships provided by their own Governments or by the host country, but a high proportion are privately financed.

Although much of the effort must come from the under-developed, there is also an enormous part to be played by the developed countries. It is a great mistake to assume that the initiative lies wholly, or even mainly, with the 'developed' countries. A vast and largely private movement is taking place spontaneously. But the developed countries can help that movement, most effectively at the higher levels, at the stage of university and technical training. They need to continue to welcome students from abroad; to supply teachers at the higher levels; and to provide and finance buildings, equipment and books. Much has already been done by the so-called developed countries. Naturally we think first of what has been and is being done by Britain, but nearly all the countries of Western Europe and the wealthier Commonwealth countries are playing a real part and the contribution of the U.S.A. is vast. I want to particularise rather more the forms of this assistance, but before doing that one general remark needs to be made.

While we should not minimise these efforts, we equally should not exaggerate

the possibilities of their expansion. It cannot be too much emphasised that 'developed' countries are also under-developed and have their own vast educational needs. They can provide neither university places nor university teachers *ad lib.* for the under-developed countries. This is not a problem of money, to be solved by large votes of funds; it is a problem of very specialised manpower. The shortage of teachers at all levels is indeed world-wide and educationalists in many countries are apprehensive that average school standards are deteriorating in consequence. Teachers are the real bottle-neck in education and they cannot be manufactured overnight.

This shortage of personnel is apparent to everyone who has practical contact with the problems. As Vice-Chancellor of the University of Malaya I was acutely aware of the difficulties of recruitment of teaching staff; competition from Government, business and other teaching institutions was too keen for the University to retain all the cream of its own graduates on its staff, and when we looked overseas we ran at once into the well-known shortages in such fields as physics, statistics, and applied economics. On the other side, as Director now of the London School of Economics, which has always been proud of its high proportion of overseas students, I see how we have every year to reject a high percentage of applications from abroad for higher degree studies because we are at the limit of the numbers our teaching staff can effectively supervise.

The answer to this problem of education for development is thus not a simple one of saying 'let the advanced countries help the less advanced'. But the lesson is none the less clear that we can help by sharing the resources that are available, so long as we remember that, as I have just said, the resources to be shared are not pounds, shillings and pence but highly trained men and women. That is being done by a multiplicity of agencies. Starting with ourselves, there are some things of long standing. British universities, living up to the best of university traditions, have always welcomed students from other countries, and the fact that so much of the universities' income comes from the taxpayer has not yet been advanced as an argument for giving preference to home students. In the past, and still to some extent today, British university organisations have helped the growth of education overseas very much by providing examination services, whether at school level through, say, the Cambridge School Certificate or at university level through the external degree examinations of the University of London. The British taxpayer makes a financial contribution through the services to students provided by the British Council and, much more extensively, through the expenditures by the Colonial Office on education out of Colonial Development and Welfare Fund. During the ten years 1946–56 those amounted to over £29,000,000. Much of that went on school-building and other general aids to education, but a specially interesting part has gone to aid the growth of universities in the British Colonies. That development has been a co-operative effort by the Government which has provided money for buildings, by leading men from the U.K. universities at large who have provided wise guidance on policy, and by the University of London in particular which has taken a number of new university colleges under its wing in very much the same way it has done for various university colleges in England. The fruit of these and earlier efforts is that there are today in British Colonies or former Colonial dependencies four universities, five university colleges, and a number of other institutes of higher education.

Turning to the Commonwealth we have the Colombo Plan. That is in fact a good deal less of a plan than is sometimes thought; it is more a collective name for a number of loosely co-ordinated pieces of mutual assistance by one Commonwealth country to another. But under it a lot of individuals in the under-developed areas have benefited by opportunities of study overseas and grants of assistance have been made to educational institutions. Moreover, the Commonwealth countries are

helping in ways quite outside the formal Colombo Plan. In Malaya the University has benefited by gifts of books from Australia and New Zealand and of engineering equipment from Australia, and a few individuals have been awarded Colombo Plan scholarships, but both those countries and Canada have helped more largely by taking large numbers of students in the ordinary way. Australia especially has taken many hundreds of students from Malaya and, of course, large numbers from other parts of Asia.

I cannot list the endeavours of all the developed countries, but the assistance offered by the U.S.A. is of a very special magnitude. Large help has been given to education in many countries under the American foreign aid programmes; American universities have opened their doors freely to foreign students and have in a number of cases taken new universities and new departments under their fostering care in a way comparable though not identical with that of London; and American private foundations, such as Rockefeller, Carnegie and Ford have given very large sums, especially for the initiation of new projects.

All this is on the national plane. There is also international activity through the Technical Assistance Board of the United Nations, through U.N.E.S.C.O. and in more specifically technical fields through F.A.O., W.H.O., the International Bank, and the I.L.O. In a sense the whole of the work of such an organisation as F.A.O. can be called educational, and the under-developed countries are, of course, the largest beneficiaries. It is, however, the developed countries which provide the greater part of the finance for these bodies and also the greater part of the technical personnel.

In running through these various activities I have been looking at the kind of things that get organised by Governments or other public bodies. But there are other channels of help which are just as valuable, or more so, but are less closely organised. First there is, of course, the flow of teachers out to the under-developed countries. Here and in most other countries that is the affair of 'authority' only to the extent that institutions at home are willing to look favourably on it and perhaps on occasion to enter into special secondment arrangements. The flow is large, varied, and vital to new universities overseas. Quoting again from Malaya, the University had while I was there still a majority of its staff drawn from 'developed' countries, but over a dozen such countries were represented. Perhaps there is not very much more than can be done formally to promote the flow, and looking at the matter now from the other end I know well the difficulties of releasing staff. None the less, I do hope that university bodies—and other employers of persons of the attainments in question—will at least go on looking as kindly as possible on special secondments, and—perhaps most important—will do everything possible to see that people who do take a period of service abroad are not thereby damaged in their prospects of appointments in this country.

Besides the flow of teachers there is the flow of ideas through books, through periodicals, and through conferences of learned men and women such as that we are now attending. Here perhaps it is for the developed countries to offer and the under-developed, if they wish, to take. Certainly I am sure that everybody here would wish to encourage meetings of learned societies and associations and would agree that all efforts should be made to make it easy for people from under-developed countries to attend them and to ensure that the problems of those countries receive attention at them. In some cases politics may interfere with both the flow of the printed word and the movements of learned men. The most obvious cases, of course, are the Communist countries, where the complete exclusion of non-Communist publications is only to a small extent mitigated by letting approved scientists have foreign scientific publications. I fear, however, that there is a real danger of less complete systems of exclusion of books and periodicals developing in non-Communist under-developed areas. Language is another obstacle to the

diffusion of ideas and I suspect that there is room for perhaps a whole series of organisations producing in a single language appropriate to a particular area summaries of scientific publications in many varied languages. The systematic establishment of such organisations would be a very fruitful piece of international co-operation.

It is thus through many diverse channels that I personally see help going out towards the enormous and never-ending task of development. If I may recapitulate what seem to me the main points, they are these. The education needed for development is education at all levels and in practically all forms; in natural science and technology, in economics, politics, and social studies, in history and languages and literature; I would perhaps concede, though I would not assert, that even education in the classics may help in development. Providing this education is a task mainly for the under-developed people themselves and a task to which a vast public and individual effort is being devoted by those peoples; but the developed can help in a multitude of ways. The most important obstacles are shortage of men and women of high capacity and high attainment, and the very intractable problems of language. No quick solutions can be found to either of these problems, but we can only make the fullest contribution to the ultimate solution if there is give and take, sharing and co-operation, on all sides. If the developed countries, the richer countries, of the world accept an obligation to share some of their educational resources, there is an obligation also on the less developed at least to refrain from making the sharing more difficult by exaggerating political, linguistic and psychological obstacles. I end, perhaps, then on the least technical note of all by urging the importance of education not in technology, not even in economics, but in mutual tolerance and goodwill. If the key to right development lies in the sharing of knowledge those who have the greater knowledge must be willing to share it and those who have less must be willing to receive it and to use it.

AGRICULTURAL CO-OPERATION AND TECHNICAL PROGRESS[1]

by

SIR FREDERICK BRUNDRETT, K.C.B., K.B.E.

WHEN THE British Association met in Dublin in 1908, the Chairman of the Agricultural Section was that great Irishman, Sir Horace Plunkett. There has never been—indeed I doubt if there ever will be—any man better qualified to speak on agricultural co-operation. I feel therefore that I cannot do better than quote the sentences from Plunkett's Presidential Address with which he introduced the subject. They were these:

> I have no hesitation in laying it down as a fundamental principle of agricultural development that organisation for business purposes is an essential condition of a demand for technical advice and of a willingness and capacity to apply it. This brings me to what is perhaps the most important of all agencies in rural progress. I refer to agricultural co-operation.

It is my purpose in this paper to show how right Plunkett was.

It is an obvious fact that the application to agriculture of new scientific and technical developments has led to great increases in productivity. This process has been going on for at least 150 years but it has been enormously accelerated during the present century and particularly since the first World War. It has not, however, been spread evenly over the world as a whole. Indeed, in some parts of Asia and Africa, agriculture today is in much the same state as in biblical times.

One of the factors which affects the ability to apply advantageously many technical advances is that of the scale of operation. Fortunately, in so far as the actual farming itself is concerned, quite moderate areas of land are sufficient to prevent this factor becoming of vital significance.

The point at which scale becomes technically important is rather in the industries and services ancillary to the farm. In primitive conditions these formed part of the economy of the farm and contributed essentially to its well-being. It is not so long since most of the processing of agricultural produce—butter and cheese making, slaughtering of livestock and curing of meat, even carding and spinning of wool—were all completed on the farm and added to its revenues. So did the retailing of these and other commodities direct from farm to consumer. It is only in comparatively recent years, with the introduction of advanced techniques of processing and marketing, that the individual farmer has been reduced to a producer of primary raw materials. If he is to regain control of processing and marketing and the returns which they bring, it can only be through co-operative action which will bring together the raw product of a large enough number of farms to make possible modern equipment and highly trained management.

On the other hand, while the output of the farm has been reduced from finished or semi-finished products to raw materials, the input, in the shape of elaborately designed and prepared feeding stuffs, fertilisers, pesticides and appliances of all types, has become vastly more complicated as well as more costly. Here, again, the importing, manufacturing and distributing processes can only be controlled by and for the farmer under some system of co-operation.

Further, the fact that the farm has become dependent on expensive raw materials and equipment from outside, taken in conjunction with the long production cycle

[1] Address delivered to Section M (Agriculture) on September 9, 1957, at the Dublin Meeting of the British Association.

of agriculture, has made the farmer much more dependent on liquid capital than in the past. This is a requirement which a banking system geared to the needs of industrial communities may not be well situated to supply.

Finally, there are services—artificial insemination is a good example—which are costly to establish and only economic if used on a larger scale than would be possible on any but the most extensive private estates.

The beginnings of agricultural co-operative organisation date from the early years of the agricultural revolution and have often appeared, especially perhaps to those who took part in them, as defensive in character. Men formed an organisation to liberate themselves from the money lender, the fertiliser merchant, the threshing contractor, or to compete on level terms with the butter merchant and the importer of cheap overseas produce. There was some justification for this view in its time and place, but because it was superficial it now appears out-dated. In fact, these persons were supplying services of scale—in equipment, capital, processing and selling—which technical progress was making essential. But since these services were no longer integrated with the economy of the farm itself, they took away with one hand what, in the way of advantage, they gave with the other. Two competing interests had arisen where previously there was only one. The basic function of the agricultural co-operative movement is to restore these extensions of farm economy to the primary producer, so that without changing the traditional unit of primary production, the farmer can continue to draw profit from the ancillary industries, using modern technology applied on an adequate scale.

What precisely should be understood by agricultural co-operation? It can be argued with a good deal of cogency that co-operatives should rightly be regarded as part, though a special part, of the system of private enterprise. They are wholly voluntary in character, they are not governmental and their objectives are economic.

What distinguishes them from other businesses is that co-operatives aim at rendering service to their membership at cost, not at earning profit by rendering services to others. The organisation is always open to fresh adherents and so can never become a group serving exclusive interests. Benefits are distributed to members as users, rather than as shareholders, the interest on capital being limited by law or rule. Individual shareholding is subject to a legal maximum and the voting rights of members (in nearly all cases one vote each) are never tied to the amount of shareholding.

These provisions may have owed something to the social outlook of those who pioneered agricultural co-operation in all countries, but they also have a sound basis in economic fact. Joint-stock companies are associations of individuals out to create a new business which will bring them a return on the capital invested. Agricultural co-operatives are associations, not so much of individuals as of existing small and medium businesses, wishing to obtain services which they cannot economically provide for themselves. The return on capital is not the primary objective. The mere fact that the basic productive unit, the farm, is more or less unalterable, means that the gain of each agricultural 'firm' does not lie in competing with similar 'firms' and putting them out of business, but in raising the general level of efficiency in the industry as a whole, through the pooling of services as well as through the pooling of technical knowledge.

In Great Britain and Ireland the primary purposes of agricultural co-operation have been to provide the farmer with the raw materials and tools of his industry and to market the product. In Great Britain the earliest development and perhaps the greatest emphasis has been on the supply of requirements, which includes the milling and mixing of feeding stuffs and fertilisers, seed cleaning and a number of other semi-productive processes. Marketing, however, has been gaining steadily in importance in the last decade and is particularly important today in eggs, wool,

grain and fruit. In Ireland this process was reversed. Manufacture and marketing of milk products came first and co-operative supply developed at a later date. In both countries co-operative services, such as crop drying and artificial insemination, have made progress in recent years.

Any co-operative conducted with even average ability fulfills its first objective of extending the economy of the farm beyond primary production. This, however, is not enough in the long run if an organisation is to be built up strong and permanent enough to make a significant contribution to national economy. Co-operatives must compete on sheer efficiency with private businesses of the same character. This calls not only for modern business management, adequate capitalisation and the best use of resources, but also for knowledge of current developments in agricultural science and technology and the use of scientifically and technically trained men who can advise both the society and its farmer members. Original research comes later and is concerned with the application of principles rather than their discovery, but may be valuable in dealing with local problems and needs. Such advisory services are not, of course, peculiar to co-operatives; they are also provided by good private firms, though it may be added that nothing stimulates competitive service from such firms more effectively than the presence of an active and enterprising co-operative. A stable co-operative, even if not rapidly expanding, is also a permanent safeguard against monopoly, more effective and less cumbrous than legal restraint.

The pursuit of efficiency in a co-operative has, of course, to take into account the special nature of its internal control. The close relation between member-customers and their organisation is an initial advantage. There is from the start a bond of common interest. On the other hand, a committee of elected farmers may be tempted to make do with amateur or inadequately paid management, or may have little idea where to draw the line between broad policy and day-to-day interference with the conduct of the society. They may be timid about expansion or, on the other hand, too ready to agree to large and ill-understood projects. These, however, are the faults of the early stages and of co-operatives which try to work in isolation.

In every country where agricultural co-operation is a business form of any importance, local societies have long ago formed themselves into large organisations. These are federal in character, so that the primary societies do not lose their identity or the local roots which give them vitality. Broadly speaking, federal organisations are of two kinds, those which carry on trade or manufacture and those which exist to advise, represent and make policy for co-operatives, usually on a national scale.

The first group owe their origin once more to the demands of scale. A successful local co-operative may handle or even mix fertilisers, but it cannot set up a modern superphosphate plant because it has not the outlets for an economic throughput; it may produce butter and even sell it successfully to local buyers, but it has not the volume to make an impression on the export market, still less to maintain selling agencies in foreign countries—hence, the wholesale organisation, the productive enterprise or the commodity marketing federation. Such organisations do not as a rule include farmers' co-operatives of all types indiscriminately. They are usually limited to those handling one or a group of closely related commodities. Sometimes, as in South Africa and parts of Australia, they are associated with commodity marketing boards, or their position may be such that the co-operative federation and the board have become virtually identical. In many cases they exercise a powerful influence on national policy in marketing and export, as well as on the policy and quality standards of the local organisations.

On the supply side, national organisation has never approached a monopoly position and is more likely to be resisting monopolies. The American and Canadian

co-operatives who supply petroleum products to their members united first for wholesale purchase, then for the operation of refineries, and finally for the acquisition of oil wells and the construction of pipelines. Their latest move has been the formation of an international co-operative petroleum association, with both distribution and sources of supply beyond as well as within the American continent.

The second type of co-operative grouping is usually national in scope and heterogeneous in composition. It serves the general interest of farmers' co-operatives as such. It is their mouthpiece, speaking to government, the press and the public. It is their legal and sometimes technical adviser. It adjusts interests and claims within the co-operative structure. It aims at knowing all there is to know about successful co-operative business and at reflecting that knowledge back on the local organisations. It has in fact to educate two sets of people and to do so with tact and resource, for it is dealing with adults who are often already very fully and sometimes, I fear, erroneously, persuaded of their own business competence. It has to provide a system of staff training, formal or informal, at least as effective as that provided by private firms. Such training will not ignore but will take advantage of the peculiar balance of power and interest in co-operative organisations. It must also educate the boards of co-operatives and the members by whom these boards are elected.

It does this in the interests of sound business and a proper balance between professional management and board responsibility. Incidentally, it is in this way contributing to the spread of what has been called 'economic literacy' among large numbers of farmers, a knowledge of the principles of management and the rules of capital investment and liquidity, together with a clearer understanding of the realities of markets, prices and costs than most would acquire on their own farms.

Agricultural co-operation, and not only its central organisations, thus plays a part both in technical and economic education. It has also done something to preserve autonomy and individual judgment in a world where minds as well as commodities are now tending to be mass produced. To quote a recent article by Dr. J. G. Knapp of the United States Department of Agriculture (printed in the *Harvard Business Review*), co-operation has given farmers

> . . . the advantage of big business—volume economies, access to managerial skills, sufficient capital for research and development. It has thus helped to perpetuate small enterprise with all its opportunities for individual expression and satisfaction, so valuable in an economy of increasingly large business firms.

On the economic side Dr. Knapp has this to say, 'Co-operatives can integrate farms with markets and with sources of supply and thus make agriculture a stronger segment of our society . . . Farming under these circumstances ceases to be isolated and becomes the heart of an integrated farm-enterprise system'.

If this is true of advanced economies like those of Britain and America, it is even more significant for the under-developed countries of Asia and Africa, where techniques are still primitive and productivity low, while population rises and new wants and hopes are stirring the once inert peasant masses. In such countries the adoption of modern techniques of agriculture and business are essential if food production is to keep pace with population, if export crops are to be marketed to the advantage both of the producers and the national revenue and political stability preserved. The basic situation is well described in a recent publication of the Economic Section of the United Nations:

> Each of millions of farm families has only a small acreage of land, few tools, little equipment and few livestock. In their own local environments these families have learned, from decades of experience and trial, how to wrest from these meagre assets food, clothing and shelter—but not in amounts and qualities adequate to prevent malnourishment, disease and early death. The opportunities which technical progress in farming open up—for

the fuller use of soils and of water resources, the raising and maintenance of soil fertilities, improvement in seeds and breeding stock, better feeding and management of livestock, fuller control of diseases and pests, better processing and storage of products—all these opportunities are grasped too slowly, or not at all. And in many countries seasonal periods of overwork continue as they have done for centuries. The amounts of soil preparation, or weeding or harvesting that can be accomplished in good time are determined directly by the limits of human physical endurance inadequately relieved by tools or machinery. During other seasons in these countries and elsewhere, serious underemployment is rife. The results are widespread poverty—physical, mental and spiritual. It is against such a background that co-operative associations as institutions for rural progress must be judged.

The order in which the problems of primitive agriculture are attacked, and the relative importance of different forms of co-operative organisation which can be brought into play will obviously differ from those in more developed countries. Often the essential condition for any technical improvement is security of tenure and an economic holding. Insecurity is usually the outcome of indebtedness, perhaps resulting in an inability to pay rent, but at least as often in the mortgaging of land which sooner or later passes to the mortgagee. The former owner may continue to work his former holding as a labourer, but he has long since lost any will to improve it. The remedy for this is the co-operative credit society or rural bank, unknown in Great Britain but universal on the Continent of Europe, in America and in most parts of the British Commonwealth. The man who has redeemed his land as, for example, thousands of Cypriot farmers have done, through a co-operative village bank, is prepared to undertake long-term improvements and to apply all the energy and skill he possesses. If to redemption is added consolidation—the substitution of a continuous holding for half a dozen scattered plots—the possibility of further development lies before him. In the Punjab before partition, over a million acres of land had been consolidated in this way through voluntary agreements carried out by village co-operatives.

Credit co-operatives play a part not only in the redemption of farms but in the capitalisation which is necessary before even the most limited improvement or re-equipment can be carried out. They also make possible the orderly marketing of crops by making advances which will enable the producer to wait until his crop has been harvested, processed and sold by his marketing co-operative, instead of taking the first offer which he gets from a merchant at or perhaps considerably before the harvest.

In theory, redemption, consolidation and re-equipment should come first in the order of co-operative development in tropical peasant countries. In practice, something more tangible and immediately attractive may be needed to arouse interest. The point of entry of co-operation in Africa was marketing—cocoa in West Africa; coffee, tobacco and cotton in the eastern and central territories. In India, although the orthodox approach was made through credit, one of the most economically successful co-operative developments is in the marketing of sugar cane. Grading, in a co-operative which will take the trouble to explain to a member the defects of his product and how they have come about, is also the best introduction to better cultivation, as the Tanganyika coffee growers have demonstrated, or to a more intelligent attitude to such unwelcome necessities as the destruction of cocoa trees afflicted with swollen shoot.

Much improvement can be brought about by a change of methods, without heavy investment in new equipment, for labour saving in the tropics has little economic meaning. Hence co-operative supply of agricultural requirements is usually a later development, and for a long time may mean little more than fertilisers.

Services, on the other hand, may be more important. Though machinery may be too expensive to use as a mere labour saver, there are climates in which speed

in cultivating or harvesting is of high importance, and mechanisation may make all the difference to food output. Again, for clearing land, deep ploughing and the eradication of certain types of weed, a machine, which may be the co-operative property of the village, can do what is beyond the power of man and bullock.

Also in the context of more or less primitive village economy, co-operation may take on social functions which in Europe or America are un-needed, or supplied by some other agency. Health services, rural electricity and water supply and local transport are examples.

Most of the countries which have reached national independence since the end of the last war lean heavily on co-operation as a means of raising the productivity of their agriculture and satisfying the aspirations of their peasant populations. The Colonial and ex-Colonial territories are approaching the same ends, if at a more leisurely, perhaps too leisurely, pace. All their leaders are aware that it is the only method which offers any chance of attaining, in the framework of a free society, that leap forward in agricultural productivity which they know to be the necessary basis of a stable modern State. They are also, however, equally aware of a rival system forever urging its claim to bigger and quicker results.

The system of the collective farm, the machine tractor station and the State Purchasing Commission has not in fact achieved results even in the technical field, perhaps especially in the technical field, at all comparable with those achieved by individual and co-operative effort among the comparatively small farms of Western Europe. This is a fact which should be made known as widely as possible. In this connection the visits of Asian and African agricultural technologists and even students to Western countries, take on a special importance. These men require to learn not only the new techniques, but the means by which in Europe the farmer has received them and has been assured of a return for his initiative.

To sum up: the adoption of systems of co-operative business in agriculture makes possible first the restoration to the farm of those auxiliary industries of processing and marketing of which technical invention would otherwise deprive it, and secondly, the continuous re-equipment of the farm itself at a high technical level, on terms which are adapted to the farmers' resources. Indirectly, through both lines of action, co-operation adds to the farmers' knowledge and understanding in the fields both of production and business.

In conclusion, may I appeal to all those who genuinely believe in the real value of agricultural co-operation not to be ashamed of their belief. In order to fix this thought in your minds, I end somewhat lightheartedly with a piece of doggerel:

The codfish lays ten thousand eggs,
The homely hen lays one:
The codfish never cackles
To tell you what she's done.
And so we scorn the codfish
While the homely hen we prize,
Which demonstrates to you and me
That it pays to advertise.

HOW STANDS THE THEORY OF GRAVITATION TODAY?[1]

by

PROFESSOR J. L. SYNGE, F.R.S.

1. INTRODUCTION

THE TWO outstanding names in the history of the theory of gravitation are Newton and Einstein. Whether true or not, the legend of Newton's apple has a profound meaning if we interpret it as indicating that gravitation is both intimate and universal. The force which presses an audience into its seats retains the earth in its orbit round the sun.

At the present time there is too great a tendency to regard gravitational theory as a tool for astronomers. We forget its immediate actuality, how we fight against gravity for sixteen hours or so out of every twenty-four. Gravity is our constant enemy, but also our constant friend, as was pointed out in his *Theory of Natural Philosophy* by a great and witty physicist of the eighteenth century, Boscovich:

> Consider, if gravity were suddenly taken away, what would become of our walking, or the arrangement of our viscera, of the air itself, which would fly off in all directions through its own elasticity. A man could pick up another from the Earth, and impel him with ever so slight a force, or even but blow upon him with his breath, and drive him from intercourse with all humanity away to infinity, never more to return through all eternity.

We might justly say that gravitation links together chairs and beds and planets and galaxies.

In this brief sketch I shall make no attempt to list the many results obtained during the past forty years by workers in Einstein's theory of gravitation, put forward by him in 1916 under the title *General Theory of Relativity*. My plan is first to lay before you the essentials of Newton's theory of gravitation, emphasising those concepts which are inherent in it, and which we may be in danger of accepting as universally valid, whereas they are in truth specifically Newtonian. I shall draw your attention to the ease with which Newton's theory solves certain problems.

Having built Newton up, I have next to tear him down, and this is not an easy thing to do. I want to insist that Einstein's theory is not just a slight modification of Newton's theory, but something radically different. The *results* given by the two theories are very much the same—in fact it is very hard to distinguish between them—but the *concepts* are not the same at all.

I then propose to lay down very briefly the essentials of Einstein's theory of gravitation and talk about certain problems. I must be forgiven if my touch is a bit erratic; one cannot, in this brief compass, attempt a systematic account of what is really a difficult and complicated theory. Perhaps I might venture on a word of exhortation to those who work on Einstein's theory of gravitation, and that is to throw off the shadow of inferiority complex which still hangs over that theory. When a theory is young, it has to be defended and justified, but Einstein's theory is no longer young. It stands on its own feet as the generally accepted theory of gravitation. If you do not like it, you can make up your own theory. But you cannot go back to Newton's theory, because it contains the concept of absolute time, and no modern physicist could stomach that. The reasonable attitude is to study

[1] Address delivered to Sub-Section A* (Mathematics) on September 5, 1957, at the Dublin Meeting of the British Association.

Einstein's theory without polemics, seeking to understand it rather than to defend or attack it.

2. Newton's Theory

Newton's theory of gravitation involves essentially the concepts of absolute space, absolute time, and force. The essential hypothesis can be put in two different ways, discrete and continuous, and the option of using either way is a powerful aid in applications.

Stated in discrete terms, Newton's law asserts that if, at time t, there are two particles of masses m and m' at a distance r from one another, then each experiences a gravitational attraction directed towards the other and with magnitude Gmm'/r^2, where G is a universal gravitational constant.

The alternative plan is to think of a continuous distribution of matter, not particles, and to introduce a gravitational potential V which satisfies Poisson's equation

$$\frac{\partial^2 V}{\partial x^2}+\frac{\partial^2 V}{\partial y^2}+\frac{\partial^2 V}{\partial z^2}=-4\pi\rho \tag{1}$$

where ρ is the density of matter at the point (x, y, z). The intensity of gravitational attraction is given by the gradient of the potential V. But something more must be added, because we may need to deal with situations in which there are surfaces across which the density is discontinuous, as at the surface of the sun or the earth. We assume the continuity of V and its first derivatives across such a surface of discontinuity—the second derivatives may change sharply.

3. The Newtonian Two-body Problem

Equipped with the above laws, the geophysicist can calculate the attraction of a mountain mass, and relate it to the deflection of a plumb-line. But the astronomer is interested in dynamical problems, and he naturally associates Newton's laws of motion with Newton's law of gravitational attraction. He is then in a position to tackle problems in celestial mechanics. Forgetting the complexity of the actual solar system, he may concentrate on an idealised two-body problem. In most of the two-body problems which come to mind, one of the two bodies is much more massive than the other (the sun and the earth, or the earth and the moon), but it is more interesting to consider the case of comparable masses, as for a double star.

The whole of theoretical physics is possible only through the application of a fantastic series of substitutions. The appalling complexity of nature is replaced by simple figments of the imagination, and this is done so easily and naturally that many physicists hardly realise that they are doing any such thing. The Newtonian physicist or astronomer has an arsenal of Newtonian models packed away in his imagination, and when he is asked to discuss a physical problem, his first act is to reconstruct a model of reality out of these imaginary pieces. His collection contains particles of no size at all, perfect spheres which are absolutely rigid, and many other things never seen on land or sea. The only limitation to his range is a sort of conceptual consistency—his arsenal contains no round squares.

Suppose now that the Newtonian astronomer thinks of a physical two-body problem and looks round his private intellectual museum for those pieces out of which he can construct a model. Very probably he will take two particles of no size at all. If he does this, he will find the two-body problem extremely easy—a mere student's exercise: each of the two bodies describes an ellipse about the other.

The Newtonian astronomer may use a more elaborate model for the two-body problem, and I shall come to that presently. But I want to dwell for a moment on this question of models of reality. The philosophers of science talk all too little about them, but they are in truth the core of the matter. If we pass from Newton to Einstein, we do not get rid of models—theoretical physics is impossible without

them. But we change the models—that is the important point. The difficulties experienced by many people arise from their attempt to use in relativity the models which are right and proper in Newtonian theory. Those point-particles which the Newtonian astronomer so gaily substitutes in his mind for the components of a double star are not available in relativity, at least not in my opinion.

To return to our Newtonian astronomer wrestling with a two-body problem, and seeking a model more realistic than that afforded by a pair of point-particles. He commits himself to bodies of finite size. Then there are some questions to be asked and answered. What shapes have the bodies, and of what are they composed —solid, liquid or gas? The astronomer is, of course, not fancy-free. He has before him some definite two-body problem, and his aim in constructing a model is to reproduce as far as possible the essential features of reality. But on the other hand, his model is useless if it is too complicated, for then he can obtain no results from it.

A two-body problem with two rigid spheres is very nice. The solution is the same as if we had two point-particles, and the finite size comes in only incidentally, the two spheres spinning with constant angular velocities. But if we insist on fluid spheres, the problem becomes too difficult, and can only be handled, if at all, by very unpleasant approximations.

My references to Newtonian theory are intended as a background for Einstein's theory, and I do not wish to go too deeply into it. But the background is important for the following reason. As a matter of experience, we know that any problem which is hard in Newtonian theory will be harder still in Einstein's theory. Thus when we come to consider the two-body problem in Einstein's theory, we shall recognize from the beginning that the problem of two fluid bodies is likely to be too hard altogether, and we shall try to deal with those models which have proved accommodating in Newtonian theory. If we cannot treat the problem of two point-particles, we might at least try two rigid bodies. But, alas, that is not plain sailing, for rigidity is a very simple basic concept in Newtonian theory, but difficult indeed in Einstein's!

The reason why rigid bodies are easy to handle in Newtonian theory is that their motion is governed by ordinary differential equations, whereas the motion of a fluid is governed by partial differential equations, and ordinary differential equations are trivially easy in comparison with partial differential equations. Even if you abandon the spherical form for the two bodies, taking ellipsoids for example, the assumption of rigidity will still keep the Newtonian two-body problem reasonably easy to handle.

4. Conservation Laws

In Newtonian theory we have delightful conservation laws, delightful by reason of their simplicity and universality. Consider any isolated system, free from all external influences. It may be as complicated as you like, solid or fluid, animate or inanimate. Then that system conserves its linear momentum and angular momentum. There is also a law of conservation of energy, but less universal as far as mechanical and gravitational energies are concerned, because these types of energy may be converted into other types, such as thermal or chemical.

Since I shall not be referring to conservation laws in relativity below, it may be well to make a remark here on the rather elusive character of such laws in relativity. One feels that perhaps old wine is being put into new bottles. Perhaps the concepts of momentum and energy, which have played so stout a part in Newtonian theory, are not the concepts suited to relativity, which must in due course work out its own.

5. Einstein's Theory of Gravitation

I have listened to, and participated in, a great many scientific arguments with great profit and enjoyment. But there is one type of argument which is irritating and

profitless, and that is an argument at cross-purposes. Two men talk about different things, but think they are talking about the same thing because they happen to use the same word for both things.

That is something we have to guard against in relativity. We have a battery of words charged with Newtonian meanings, and we discharge them against relativistic objectives with sad and confusing results. From this confusion we retreat into mathematical notation, which has a far greater clarity than ordinary words, at least for those who understand it.

I often wonder what the world looks like to a person who has no mathematics beyond that required to balance his accounts. I think it must appear very dull and very woolly, since no precise thought is possible without mathematics. But it is not merely a question of precise thought. It is much more. It is coming to be realised that mathematics is one of the keenest weapons in the battle of material scientific progress—that men and women can earn money by being mathematicians —and probably the economic attraction will lure more young people into mathematical studies. But I feel that that is only part of the picture. It is in the nature of man to wonder at the nature of the universe in which he finds himself, and, not stopping at wonder, to try to understand it. This theory of relativity about which I am speaking was a wonder to the world, but of those who wondered what utterly infinitesimal fraction ever understood the least thing about it? They could not, because they did not know the alphabet of the language in which it was expressed.

I suppose that this is not the time or place to let off too loud a blast of indignation at the place which mathematics at present occupies in the scheme of education, and the tradition according to which it is an intellectual discipline instead of the greatest of all intellectual adventures. It might be more effective to appeal to that snobbery which is latent and powerful in all of us, and suggest that any educated man or woman in the year 1957 should be as ashamed of not knowing what a function is or what a derivative or an integral is, as they would be ashamed of not knowing how to spell correctly or of not knowing how to write a reasonably grammatical sentence. Or I might refer to aesthetics and assert that anyone acquainted with the arts and with mathematics will recognise in mathematics an aesthetic quality which makes the other aesthetic qualities, more widely understood, look rather childish and silly.

Having let off steam, let me turn to Einstein's theory of gravitation and try to present it in a nutshell. The key-word is *event*. Each event is described by four co-ordinates x^1, x^2, x^3, x^4, or briefly x^r ($r = 1, 2, 3, 4$). The totality of events form therefore a manifold of four dimensions (space-time), and we are tempted to think geometrically about this four-dimensional space, using familiar words from familiar geometry. It is a temptation to which we will do well to yield, following Minkowski, who by introducing the geometrical element into relativity gave us an excellent mode of thought, which, in my opinion, has been insufficiently exploited by workers in relativity.

We think of a set of functions of the co-ordinates, denoted by g_{mn}. Taking $g_{nm} = g_{mn}$, we see that there are ten of these *gravitational potentials*, as they are called. These potentials are linked to the physical concept of *proper time* (measured by a standard clock or atom) by the equation

$$ds^2 = -g_{mn}dx^m dx^n, \tag{2}$$

where ds is the element of proper time which elapses as the clock experiences the adjacent events x^r and $x^r + dx^r$. The suffixes m and n are to be summed over the values 1, 2, 3, 4.

If we use the word *distance* for ds, merely for the sake of analogy, we recognise that we have before us a Riemannian space of four dimensions with a measure of distance given by (2). This increases the value of the geometrical line of thought.

Gravitation manifests itself as a *curvature* of space-time. To find whether there is a gravitational field or not, we calculate a set of quantities R_{abcd} (the Riemann tensor—it has twenty independent components), and if any one of the components is different from zero, then a gravitational field is present.

Throughout Einstein's theory, two modes of thought are open to us, and the most effective plan is to keep them both in mind. There is the purely formalistic way, in which we cover the paper with formulae; the other is the geometrical way, in which we draw sketches and use the language of geometry, speaking of points, curves and surfaces of two and three dimensions. The geometric representation before us is a frozen image showing the history of the universe. We must be very cautious about using the kinematical pictures so familiar in Newtonian theory, for the Newtonian idea of time has been washed away.

But we have not yet got to the heart of the matter—Einstein's field equations. They read

$$G_{mn} = -\kappa T_{mn}. \tag{3}$$

There are ten equations here, since the quantities are symmetrical. G_{mn} stand for the components of the Einstein tensor, rather complicated expressions involving the g_{mn} and their first and second derivatives. κ is merely a universal constant. T_{mn} is the so-called energy-tensor of matter. I have written down the simpler form of equations without the cosmological constant; this will suffice for our purposes.

Comparison of Poisson's equation (1) with Einstein's equations (3) shows an analogy between them, and indicates the greater complexity of Einstein's theory. Instead of one potential function V, we now have ten potential functions g_{mn}, and matter is described, not by one density ρ but by ten quantities T_{mn}. But, as a matter of fact, Einstein's equations say more than Poisson's equation, because in fact they incorporate the equations of motion of the gravitating medium. This is a fact perhaps not sufficiently well realised.

In dealing with Newtonian theory, I remarked that we must make certain continuity assumptions with regard to a surface across which the density is discontinuous. For a long time the relativistic analogue remained obscure, but this obscurity was removed by A. Lichnerowicz[1] who gave the necessary hypothesis by asserting the existence of some system of co-ordinates in which the g_{mn} and their first derivatives were continuous, even across a 3-space of discontinuity of T_{mn}. This is the obvious analogy of the assumption made in Newtonian theory.

6. Fields in Vacuo

In a vacuum, we put $T_{mn} = 0$ in the field equations (3), obtaining simply

$$G_{mn} = 0. \tag{4}$$

Here we have ten equations for the ten potentials g_{mn}, or so it appears. But actually there are four identities derivable from (4), and in fact we have only six independent equations. This may seem distressing, but all is well if we recall that the co-ordinates in space-time may be chosen arbitrarily, and we can choose them so that four of the ten potentials have assigned values. For example, we can always make

$$g_{14} = g_{24} = g_{34} = 0, \quad g_{44} = -1. \tag{5}$$

Such equations are called *co-ordinate conditions*. Thus we have essentially *six* equations for *six* unknowns (the other g_{mn}), and so we have apparently a well-defined problem, the number of equations being equal to the number of unknowns.

At this point we may start a guessing game, if we feel so disposed. We can try to guess functions g_{mn} to satisfy (4). Any successful game will give us a gravitational

field *in vacuo*, provided that the chosen potentials do not happen to satisfy also the flatness equations

$$R_{abcd} = 0. \tag{6}$$

Undirected guessing, however, is not very profitable, and we must not describe as mere guesses the fields obtained by A. H. Taub[2] and by H. Bondi,[3] which fields contain no matter at all anywhere. Bondi's field is particularly interesting, because it represents plane gravitational waves and clears up in an accurate way a controversy as to whether such waves can exist at all. These waves travel, as we might expect, with the velocity of light.

One of the disappointments of general relativity is that, if we do succeed in working out a solution, it comes so near to the Newtonian solution that practical people do not get at all excited about it. But gravitational waves are quite impossible in Newton's theory—they would not make sense—and it is a great satisfaction to have before us some physical reality predicted by relativity and non-existent in Newton's theory.

Experimentalists display an almost superhuman ingenuity when their interest is roused. Unfortunately, the theory of gravitation is not a fashionable subject at present among physicists, but there is no harm in throwing out the suggestion that an instrument capable of detecting gravitational waves would be very interesting. The bob of a heavy pendulum at rest exerts a gravitational field in its neighbourhood, very small it is true, but no one would deny its existence. If the bob is brought to rest in a new position, the gravitational field will be changed, and if the bob is allowed to oscillate, there will be a fluctuating field. Indeed, we might expect that the oscillating pendulum would set up a train of outgoing gravitational waves. When we consider how small the gravitational mass of the bob of the pendulum would have to be, and how minute the fluctuations in the gravitational field in consequence, it would seem that the detection of these gravitational waves is well beyond the scope of any apparatus we can think of. But there are surely devices we have not yet thought of and brains to think of them.

But leaving imaginary experiments and returning to theory, I feel that Bondi's plane waves are only the beginning. They have in them something of the nature of a guess, and there is something to be said for a general approach. It is a question of solving a set of non-linear partial differential equations (4). In dealing with ordinary differential equations, we think of a general solution containing arbitrary constants which can be adjusted to fit given initial conditions. Partial differential equations have to be thought of a bit differently. It is vain to seek a general solution. Instead, we should work from initial conditions, assigning the values of the g_{mn} and their first derivatives on some selected 3-space in space-time. We have then what is called a *Cauchy problem*, and Lichnerowicz has studied the Cauchy problem for the equations (4). This seems to open the way for a more general study of gravitational waves. I had hopes at one time that I was on the track of a gravitational wave like a smoke-ring, but I fear it may only have been a pipe-dream.

7. Fields with Matter

In the case of Newtonian theory, only one characteristic of matter contributes to the gravitational field—its density. But in Einstein's theory we have the whole energy-tensor T_{mn} with ten components, and we may feel a bit embarrassed in deciding what energy-tensor to take to represent a given physical distribution of matter. It is commonly accepted that, for an incoherent dust, we are to take

$$T_{mn} = \rho u_m u_n, \tag{7}$$

where ρ is the density of the dust and u_r a unit vector (4-velocity), and there is a slightly more complicated formula for a perfect fluid. But, as I remarked earlier,

even in Newton's theory a fluid is a pesky thing, and we hanker after that beautiful Newtonian concept—the rigid body, or at least a body which moves as if it were rigid.

A suitable definition of rigidity in general relativity was given by N. Rosen,[4] and independently by Salzman and Taub,[5] and Dr. C. B. Rayner of our Dublin Institute is now trying to put this definition to work. The mode of attack is rather too complicated to describe here.

A stern puritanical conscience in physics demands that we should look at nature, see some problem, and try to solve it. Since we see matter and do not see gravitational fluids (only their effects), the conscience suggests that we should find the field of an assigned distribution of matter, and this may be quite a difficult job, even in Newton's theory. But why not give the conscience a rest, and look at things the other way round? Why not write Poisson's equation in the form

$$\rho = -\frac{1}{4\pi}\left(\frac{\partial^2 V}{\partial x^2} + \frac{\partial^2 V}{\partial y^2} + \frac{\partial^2 V}{\partial z^2}\right), \tag{8}$$

choose the potential V, and calculate the density by the mere operation of differentiation? Similarly, why not write Einstein's field equations in the form

$$T_{mn} = -\frac{1}{\kappa} G_{mn}, \tag{9}$$

assign the gravitational potentials g_{mn} as we like, and calculate the energy-tensor of the matter which gives this field? As a matter of fact this gives us a little more than we would get in the Newtonian case, using Poisson's equation, for Poisson's equation does not include the equations of motion of matter, whereas Einstein's field equations do.

I realise that the puritanical conscience disapproves of turning the tables like this, and that the matter obtained by an arbitrary choice of g_{mn} might be weird and not like any known matter, but I recommend such calculations to any convalescent mathematician who is not up to a greater effort; all he has to do is to choose g_{mn} and carry out some differentiations—he might hit on something interesting.

8. The Relativistic Two-body Problem

The relativistic two-body problem is a great challenge. In a famous paper, Einstein, Infeld and Hoffmann[6] attacked not only the two-body problem but the n-body problem, using an elaborate method of successive approximations. The method has since been improved by Infeld.[7] But I have never been able to get enthusiastic over such an orgy of formulae, for I cannot regard their conclusions as logical deductions from Einstein's field equations. Perhaps I am obtuse in this respect, but I would prefer to hurry slowly.

Let me try to analyse the two-body problem. In space-time I see two world-tubes, one for each body. Inside each tube Einstein's equations (3) are to be satisfied, T_{mn} being the energy-tensor of matter, and outside the tubes we are to put $T_{mn} = 0$. We have to find g_{mn} to satisfy those equations, with certain continuity conditions across the walls of the tubes, as indicated by Lichnerowicz. But we expect more than this. We expect that the forms of the two world-tubes will be found, for that is equivalent to saying that we expect the motions of the bodies to be determined. But what are the initial data? We are in a field theory, and the initial data will be spread over a 3-space, which we might regard as being $t = 0$. The history of the bodies will depend not only on their initial positions and velocities, but also on the initial field in the vacuum between them. It is a problem in partial differential equations, not in ordinary differential equations.

And of course we must say what sort of matter the bodies are composed of. We know from Newtonian theory that fluid bodies will cause great difficulty. I cherish the hope that perhaps one might be able to do something with bodies in rigid motion, but it may be that this will prove abortive.

9. Conclusion

It took about two centuries for mathematical physicists to gain a thorough mastery over Newtonian theory, and indeed they are still working hard at it—to mention one instance, the theory of water waves is still far from complete. In spite of the enormous increase in scientific activity in the past century, I feel that it is going to take a long time before we feel a like mastery over Einstein's theory. It is, of course, possible that before everything has been squeezed out of it, it will fall out of currency through the discovery of a new theory. But as matters stand at present, I think we may look forward to a good hundred years of hard work. I think it foolish to exaggerate our achievements, and I think it foolish to hurry. It is very irritating to be told that so-and-so has proved such-and-such, and to find on closer investigation that the argument is too flimsy to carry conviction.

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THE EUROPEAN COMMON MARKET AND BRITISH INDUSTRY[1]

by

MR. H. H. LIESNER

IN 1955 the six countries constituting the European Coal and Steel Community—Belgium and Luxembourg, France, Germany, Italy, and the Netherlands—decided to examine the possibility of freeing the whole of their mutual trade from all artificial barriers. Roughly a year later, when concrete proposals in this direction had emerged in the shape of the Spaak Report, Britain declared her intention of participating in the free-trade scheme. Since then, negotiations have been carried on about the precise form which this participation should take; as the British approach differs from that of her Continental neighbours in many important respects, it is not yet certain that the United Kingdom will in fact enter a common market in Western Europe.[2] However, this does not appear to preclude discussion of one very important issue which is raised by the present proposals—the effects on particular British industries of freeing intra-European trade. This is the subject of the present paper.

As a result of removing tariffs and other impediments to the free movement of goods, a country will tend to specialise on those commodities in which it has a comparative advantage, and it will tend to give up other lines of production in which it is, by comparison, at a disadvantage. In other words, the abolition of trade barriers will induce a movement of resources from the relatively less efficient to the relatively more efficient industries. The subject matter of this paper may therefore be described more precisely as an attempt to divide the commodities produced by British industry into two groups—the first comprising those commodities which have a comparative cost advantage, and the second those which are at a comparative cost disadvantage. In other words, the first group comprises goods which can be produced more cheaply in Britain, relative to the goods in the second group, than on the Continent, and the second group comprises goods which can only be produced at a higher cost in Britain, relative to the cost of producing the goods in the first group, than they can in Western Europe. Commodities found in the first category are therefore likely to do well in a common market—viz. not only will the particular industries concerned retain their home market, but they would also be expected to increase their exports to the Continent; on the other hand, industries producing commodities found in the second category would probably find it increasingly difficult to retain a substantial share of their internal market, and would also tend to lose any Continental sales which they might at present enjoy.[3]

[1] This is a slightly amended version of a paper read before Section F of the British Association for the Advancement of Science at its 1957 Annual Meeting in Dublin. I am deeply indebted to Mr. Rodney Crossley for compiling most of the statistics, and to Professor J. E. Meade for suggesting a number of important changes in the exposition. My wife rendered valuable assistance at every stage of the work.

[2] The terms 'common market', 'free-trade area', etc., will be used interchangeably in this paper, as the distinctions which exist do not matter for our purposes.

[3] It may be asked how it is at present possible for Britain to export to the Continent those goods in which she is, relatively speaking, at a comparative cost disadvantage, as such a disadvantage should theoretically tell against the products concerned when they are sold abroad. Two main reasons may be advanced for the existence of such exports. First, the export goods concerned may be highly specialized, and secondly, the industries concerned may pursue discriminatory pricing policies. In so far as the first point holds, exports may continue even if the internal market is invaded, but if—as the author believes—the second reason is the more important one, then the loss of the home market would obviously also reduce exports to the Continent.

One point, closely related to the above, deserves particular emphasis, because it appears to have been the subject of much confusion. It has been suggested in some quarters—which are not usually very amiably disposed towards the common-market project—that free trade in Western Europe would have depressing effects on British industry in general and that it would lead to balance of payments difficulties, unemployment, and social losses, although a few lines of production, such as the manufacture of aircraft and atomic energy equipment, might benefit. On the other hand, enthusiastic supporters of the project have predicted that, apart from a few exceptions, such as the cotton sector, firms in this country could easily stand up to unfettered foreign competition and would, in fact, register substantial gains in European markets.

It is true that these propositions represent possible alternative short-term situations, although they both fail to impress one as realistic forecasts; however, they cannot in general be regarded as possible long-term equilibrium positions. It is one of the essential tenets of the law of comparative costs on which any discussion of this issue is ultimately based, that if the free-trade countries maintain balance of payments equilibrium, any increase of output and of exports in some lines of production, brought about by the institution of free trade, will be accompanied by a decrease of output and an increase of imports in other lines. Professor Meade's paper 'The Balance-of-Payments Problems of a European Free-Trade Area' (cf. *Economic Journal*, September 1957) dealt with the methods by which chronic balance of payments surpluses and deficits may be avoided in a free-trade area, and therefore I do not propose to discuss this matter further; in this paper, I shall merely assume that in the long-run balances of payments will more or less be kept in equilibrium. In such a situation, it is not possible for all or nearly all industries to expand or to contract; if Britain has a comparative advantage in some industries, which therefore tend to expand, she will *ipso facto* have a comparative disadvantage in some other industries, which will therefore tend to contract.

It may appear unnecessary to give such emphasis to what most people will regard as very obvious points, but they do need to be clearly understood not only for the purpose of this paper, as will become clear below, but also for a correct appreciation of the whole common-market project.

I now come to the main part of this paper—the prospects for the different commodities produced by British industry, or technically speaking, a study of comparative costs in Britain relative to those on the Continent. It will hardly be necessary for me to point out the enormous difficulties which any attempt to make a reliable forecast cannot fail to encounter. Much water will flow under Europe's bridges before free trade in Western Europe is established, and many important aspects of the whole problem may well change in the meantime. Nevertheless, it should at least be possible to give an indication of likely trends, and this is what I have tried to do.

There appear to be at least three ways of ascertaining the position here. First of all, there is the European census of production. If it were possible to hold a detailed statistical enquiry into the whole of industry in each of the member countries of a common market, using the same methods of investigation, comparable material could be collected which should serve as a fairly accurate guide as to what would happen once trade barriers have been abolished. Evidently, such a census of production, if it were to be undertaken at all, could be staged only by an authoritative international body which could command the necessary funds; it would obviously be far beyond the reach of an individual investigator like myself. One might attempt to use the existing national censuses of production for our purposes, but even then the work involved would very likely be enormous; moreover, the additional pitfalls which such a course of action would entail might well render the results a good deal less reliable.

Secondly, one might approach firms and industries in Britain and perhaps also on the Continent and ask them how they expect their particular products to be affected by the common-market project. As most enterprises should be able to to evaluate the relative position of their Continental competititors, this method is also likely to yield fairly sound results. Difficulties may, however, arise because the crucial assessments are being made by different people, probably on the basis of different kinds of information, and possibly relating to different aspects of the effects of the common-market venture.

This second way has been followed by all the enquiries which I personally know of, and this is the main reason why I decided against it. Instead, I have attempted to judge the prospects of different British products by their relative success (or failure) in export markets in the last few years. The basis of my argument, therefore, is the assumption that Britain has a comparative cost advantage in those products which in the recent past have enjoyed relatively large sales in markets where they are in direct competition with rival products from the Continent, and that she is, by comparison, at a disadvantage with regard to those products which, relatively speaking, have been outdone by exports from Britain's European competitors. On the whole, this appears to be a reasonable hypothesis, although there are a number of difficulties connected with this approach which will be discussed below.

My first task is to describe in somewhat greater detail the investigations which I have carried out. I began by comparing the absolute level of British exports of sixty manufactured commodities to Western Europe with those of each of the six European Coal and Steel Community countries and of Sweden during the period 1953 to 1956. In many cases, a test of this nature will yield reliable results, but there are dangers in using absolute export levels only; it is possible that although some British industries enjoyed relatively large sales during these years, they rapidly lost ground over the period, and vice versa. Hence the above set of data was supplemented with the rate of increase of exports in each group from each of the countries to Western Europe between 1953 and 1956. The absolute levels of sales and the rates of increase formed the basic material. In addition, the ratio of British exports of each item to Western Europe to British imports of the same item from Western Europe was examined.

The sixty commodities chosen include nearly the whole range of manufactured goods. I have attempted to make the items as homogeneous as the basic data will allow, but there are a few instances in which the existing statistics do not provide a detailed break-down, with the result that the composition of such items may vary substantially from country to country. Thus if one takes a first preliminary glance at the table, it will be found that only two entries are available for electrical goods—'other electrical goods', and 'electric generators, transformers, etc.', ranked as numbers 30 and 31 respectively. The first group may comprise such different commodities as electric light bulbs and radio equipment, electronic apparatus and automatic toasters. Therefore, generators apart, my data cannot help me to assess the prospects for different branches of the electrical industry, although I can say something about electrical goods as a whole. Likewise for numbers 21 and 54.

The countries to be considered in this comparison really chose themselves, except perhaps Sweden, but as her exports of manufactures are quite large in some lines, and as she may well become a member of a free European market, it seemed wise to include her.

The choice of years was likewise a straighforward matter. What I required was a recent period, not so short as to give undue emphasis to the effects of random disturbances, and in general representing as closely as possible 'normal' trading relationships. The period from 1953 to 1956 appeared to be by far the best choice.

A brief word also about the market selected for the comparisons. The choice naturally fell on Western Europe, or, in terms of the trade statistics, the 'remaining O.E.E.C. member countries combined', although, for a number of reasons, this could lead to distorted results. Perhaps the most serious difficulty arose because for each single country's exports the destination 'remaining O.E.E.C. countries combined' includes all the other competitors. This means that when one is for example comparing the United Kingdom with Western Germany, British exports include sales to Western Germany, but not, of course, sales to the United Kingdom, and German exports include sales to Britain, but not, of course, to Western Germany, with the result that one is not in fact contrasting the performance of German and of British exports in the same market. If one could generally assume that in the two countries market conditions for the other's products including tariffs and other trade restrictions were fairly similar, this would not matter much, but there is probably little justification for such an assumption. The best solution would be the exclusion of all mutual trade, but there was no time for the heavy additional work involved, and therefore the export figures do include the mutual exchange in each product group. However, a wide sample indicated that this imperfection in the basic data affects our analysis only to a very minor extent, and hence it does not appear that the validity of the investigation is greatly impaired in consequence.

A second, related difficulty springs from the remnants of discrimination in the O.E.E.C. market. It is true that as a result of the O.E.E.C. liberalisation programme and of the multilateral payments mechanism of the European Payments Union most of the trade in Western Europe is now free from discriminatory influences. However, many O.E.E.C. countries still maintain a hard core of import restrictions, some of which favour certain suppliers more than others; also, nearly all British products enjoy preferential treatment in Ireland; and finally, the institution of the European Coal and Steel Community has created a free trade area with regard to certain products in Western Europe from which the United Kingdom is at present excluded. In this last case the effects upon relative exports are very noticeable, and therefore the comparison of sales of iron and steel products (no. 54 in the table) is not very meaningful, but how far the other divergences, from a non-discriminatory market are important, is difficult to establish off-hand, though the probability of major distortions arising appears to be small.

I have devoted some attention to the details of my approach so as to put the analysis into its proper setting. I shall now move on to the results of the investigation, presented in the table. This is rather a long and complex table because I thought it appropriate to provide as much information as possible, but nevertheless it should not prove too difficult. In any case, if one does not intend to probe into the facts lying behind the results, one need go no further than column 1, which ranks the sixty commodities in the order of their relative success in Western European markets, beginning with the best and ending with the worst performers.

Column 2 contains the annual average of the absolute value of United Kingdom exports of each product to Western Europe during 1953 to 1956, and the figure underneath shows British exports of each item in 1956 as a percentage of those in 1953. We will call this the index of growth of British exports. Thus during 1953 to 1956 British exports of aircraft to Europe averaged $m 40·7, and the index of growth was 157 per cent.

Column 3 contains the data relating to Britain's three most important competitors, from which the ranking of the sixty product groups is derived. The figures are expressed as percentages of the relevant British figures, and the capital letter denotes the particular country concerned. Taking the case of aircraft again, the top row indicates that exports from Italy, Britain's nearest rival, were only 10·3 per

cent or about one-tenth of the British total; next came the Netherlands with 8·9 per cent, and then Belgium/Luxembourg with 3·6 per cent. We will call these figures the indices of relative levels. The second row shows the indices of growth of exports of aircraft from Italy and Belgium/Luxembourg as percentages of the index of growth of British exports of aircraft.[1] Thus, the index of growth of Italian exports of aircraft (not given in this table) was 203·5 per cent, which is 129·8 per cent of the British index of growth, and the index of growth of exports from Belgian/Luxembourg (again not given in this table) was 690 per cent, which is 440 per cent of the index of growth of British exports. We will call these figures the indices of relative growth.

The table therefore contains: (1) one set of absolute figures—the annual average of the value of United Kingdom exports; and (2) three sets of indices: (i) the indices of growth of British exports—exports in 1956 as a percentage of those in 1953; (ii) the indices of relative levels—the absolute value of exports sold by Britain's rivals expressed as a percentage of absolute British exports; and (iii) the indices of relative growth—the index of growth of exports of Britain's main rivals expressed as a percentage of the British index of growth.

I do not propose to go through the results commodity by commodity for this would take up far too much space; rather, I shall comment on some of the more general aspects of the table, using particular items as examples wherever appropriate.

As a brief examination of column 3 will show, the figures relating to Britain's competitors present anything but a clear-cut picture. In particular, the indices of relative levels and the indices of relative growth often give conflicting results. Compare, for example, numbers 10 and 18—woollen and worsted fabrics, and aluminium. Taking aluminium first, Germany exported slightly more to Western Europe than did Britain, and France as much; the third competitor—Belgium/Luxembourg—was relatively unimportant. On the other hand, both Germany and France, especially the latter, lagged behind the United Kingdom's rate of increase. In the case of woollen and worsted fabrics, the position is more or less the reverse. The absolute value of British exports was larger than that of any competitor, the nearest rivals being Italy and Belgium/Luxembourg. In contrast, the index of growth of British exports is very much lower than those for her chief rivals, the figure for Italy being particularly high. In other words, aluminium shows up worse than woollen fabrics as regards the indices of relative levels but shows up better as regards the indices of relative growth. There appears to be no *a priori* way of settling the question as to which of these two products should be regarded as the more successful line, it all depends upon the relative weights accorded to absolute values and rates of change respectively by individual examiners, and here opinions will very likely differ. In my view, the absolute values are on the whole somewhat more telling than the rates of change, largely because rates of change are of necessity calculated from two single years and are therefore much more liable to be distorted by random shifts in the pattern of trade than are averages. In addition, the significance of a rate of change very much depends upon the relative size of a country's exports; a doubling of your sales abroad is very much easier if you start with only a small share of the market than it is if you are already the dominant exporter.

For these reasons, I made the following adjustments. In order to meet the last point above, the indices of relative growth were weighted with the indices of relative levels; the resulting figures were then divided by 2 so as to give less emphasis to the rates of change, and finally added to the indices of relative levels themselves. With one figure only for each country, the ranking presented little further difficulty—by adding the results for the three countries

[1] The Dutch figure is not available in this particular case.

together, all the information about each product was reduced to one single figure.[1]

Of necessity these adjustments have been rather arbitrary, and one might equally well have followed another procedure, with different results emerging. However, the precise order in which the commodities are ranked is not really of great importance for our purposes. All that really matters is the overall positioning of any product in the table, and in view of the marked decline in the standard of performance as one moves down the table this is much more rigidly circumscribed. In other words, unless one changed the whole approach—e.g. by giving to the indices of relative growth substantially greater emphasis than to the indices of relative levels—the ranking of our sixty products is likely to be much the same as that shown in the table whatever the precise procedure adopted.[2]

Further support for the ranking shown in the table comes from the following test. Unless the less efficient industries in Britain are protected more strongly than the more progressive lines of production, one would expect present imports of those commodities in which Britain has a comparative advantage to be smaller, relative to export sales of the same commodity, than imports of those goods in which she is comparatively less efficient. I therefore calculated the ratio of the exports of each product group to Western Europe over the imports of the same product group from Western Europe during the average of our four years 1953 to 1956, and then ranked the results. The list of commodities which emerges bears a fairly close resemblance to that presented in the table, and the rank correlation coefficient works out at 0·725. This is quite a satisfactory result, especially as a rough examination of the tariff indicated that the less efficient industries in fact enjoy a somewhat higher level of protection than those in which Britain appears to have a comparative advantage.

The other major comment on the table which I think should be made relates to the fact that in general the United Kingdom's record in the Western European market is worse than that of her competitors. As a closer glance at column 3 will show, in the great majority of cases average British exports have been lower in absolute value than those of Germany, the most important exceptions being aircraft (No. 1), tractors (No. 2) and woollen fabrics (No. 10), and frequently the United Kingdom only takes a third or fourth place; moreover, the rates at which her sales have expanded are nearly always lower than those of several of her rivals. There are, of course, explanations for these facts; for example, Germany's predominance in Western Europe is more than offset by heavier British sales elsewhere, especially in the Commonwealth, and the relatively slow growth of British exports of manufactures is at least partly due to the degree of inflationary pressure in Britain which exceeded that in most Continental countries. However, the reasons for Britain's failure to show up well are not really very significant for this analysis; what is much more important is to remind oneself that a relatively poor performance

[1] *E.g.* the ranking number for group (2)—tractors—is derived as follows. The relative performance of German exports is $\frac{190 \cdot 8 \times \cdot 712}{2} + 71 \cdot 2 = 139 \cdot 1$;

that of Italian exports is $\frac{397 \cdot 0 \times \cdot 05}{2} + 5 \cdot 0 = 17 \cdot 9$;

and that of Swedish exports is $\frac{191 \cdot 0 \times \cdot 057}{2} + 5 \cdot 7 = 11 \cdot 1$.

The ranking number for tractors, therefore, is 168·1. In four instances, the rate of increase of exports is not available for one of the three competitors, and therefore it is impossible to calculate indices of relative growth. As all four cases are only of small quantitative significance, a 'likely' rate of growth was simply guessed at when the ranking number was calculated.

[2] Two alternative methods of ranking were tried by the author. The first consisted of dividing the unadjusted indices of relative growth by 2 and then adding them to the indices of relative levels; in the second instance, the weighted indices of relative growth were added to the indices of relative levels without the division. In both cases results very closely approximated those in the table.

on the part of most British exports does not mean that by and large British industry will be affected adversely by the creation of a common market. As I pointed out at the beginning of this paper, it is highly unlikely that either the extreme optimists or the extreme pessimists will be correct, unless we allow for chronic and marked balance of payments disequilibria; if we assume that trade will be roughly balanced[1] then the dividing line between promising and suspect industries will probably lie somewhere half-way down the order, though for a number of reasons which I will mention below, it is impossible to predict its exact position. What the table is intended to do is to indicate the position of different British export goods relative to one another, by means of comparing the performance of each product with that achieved by the corresponding exports of other countries; whether from some absolute point of view British products have on the whole been successful in Western Europe or not, is quite a different question, and one of little concern to us here. In other words, our chief interest lies in the comparative cost position in Britain, i.e. the costs of different products relative to one another, as compared to the situation with regard to the same goods on the Continent, and it is on this point that we look for guidance from our table. If we were to concentrate on the absolute performance of British goods, we would be moving along the same channels of thought as the person who reasons about international trade in terms of absolute and not comparative costs, thereby disregarding the whole of the theoretical development of this subject since Ricardo.

There are, however, a number of reasons why the figures in the table may fail to indicate the comparative cost position correctly. One factor in particular should be mentioned. Above I touched upon the probable influence of inflationary pressure upon the various countries' exports. If one could assume that the degree of this pressure had been more or less the same as far as any one country's exports are concerned, the relative position of our sixty commodities would not be disturbed. However, such an assumption can hardly be made; e.g. it would be difficult to find much support for the hypothesis that because of excess demand at home all British industries had in equal measure been prevented from maintaining their export sales, and likewise for the other countries. This means that the relative position of our sixty commodities may be influenced not only by comparative costs in Britain and in Western Europe, but also by the incidence of inflationary pressure in Britain and on the Continent, with the result that our findings may be distorted. To some extent one may be able to assume that on the Continent and in Britain the same commodities were in short supply, and then our figures stand, but a great deal of effort would be required to prove or disprove this hypothesis.

Let me give an example of the kind of problem I am talking about. Number 55 in the table is cement. As its position in the table indicates, the performance of this commodity was poor. Moreover, it also shows up badly in the second test, which is the relation of British exports to O.E.E.C. countries to imports from O.E.E.C. countries. The conclusion is that the cement industry will do badly in a European common market. However, suppose that cement were particularly scarce in Britain during our period, whereas it would relatively easily have been obtained on the Continent. Such supply conditions would lead to low exports from Britain although cement might in fact be a commodity in which this country had a comparative advantage. Given a few years in which to investigate internal markets for each of

[1] This, of course, does not mean that there must be a balanced exchange of manufactures between Britain and Western Europe; as Professor Meade points out (cf. *Economic Journal*, September 1957, pp. 378–380), the object of balance of payments policy for a member of a free-trade area will be the same as that for any other country—i.e. an overall balancing of international payments. However, it is hardly feasible that this object could be attained if there were any radical changes in the overall economic structures of the participating countries (e.g. in the distribution of resources as between industry and agriculture), such as are implied in the more extremely optimistic or pessimistic views concerning the effects of free trade on British industry.

our products, this kind of error could be narrowed down; all I can do here is to hope that distortions are not too serious.

It is not difficult to think of further reasons why my results may not give a correct picture of the comparative cost position. Therefore I would again point out that the precise order in which the commodities are arranged must not be taken as anything very definite; all that I think can be claimed for my data is that allowing for some exceptions, they probably indicate the overall position of the different commodities correctly.

There is one final aspect of the figures in the table which is worth mentioning. There do not appear to be any very definite results which emerge with regard to broad sectors of industry. E.g. one cannot say that Britain has a definite comparative advantage in engineering products, for it will be found that whilst aircraft, tractors, and power-generating machinery occupy the first three places in the table, passenger cars, commercial vehicles, office machinery, and machine tools are placed very much further down in the order. It is true that engineering goods are on the whole to be found in the upper half of the table but the spread is still remarkable. Likewise for chemicals—inorganic and, especially, organic chemicals are placed a long way down the list, whereas chemical products such as paints and varnishes, or cosmetics, soaps and polishes, are in a very much better position. The same again holds for the textile industry; woollen fabrics show up well, and cotton and woollen yarns also appear in the upper half of the table, whereas cotton fabrics and synthetic yarns are placed further down in the ranking order, and synthetic fabrics are among the last ten commodities. The upshot is that if the table does rank our sixty products more or less accurately, the prospect is one of relative gains and losses within each industry; thus soaps will do better than organic chemicals, tractors better than office machinery, etc. On the whole, this seems to be a rather plausible result. For different industrial groupings, say 'new products' and 'old products', one may be able to obtain more systematic results.

It may have been noticed that I expressed myself in rather vague terms just now when I discussed the prospects for different industries—I talked about 'relative' gains and losses, and about some products 'doing better' than others. This was done quite deliberately, for as it stands the table does not allow one to say anything else. The results of the investigation so far indicate the relative position of any one of sixty products; e.g. no. 24—agricultural machinery—should do better than any of the goods further down the list, but worse than any of the preceding items. This, however, does not imply anything definite with regard to the absolute prospects of any commodity; thus, we still do not know whether production and exports of agricultural machinery will expand rapidly, or whether there will be little change, or whether imports will exert a steady mounting pressure, assuming again that total trade is balanced. In other words, there has as yet been no attempt to divide the sixty commodities into the two groups mentioned at the beginning of this paper; as I then indicated, those commodities placed above the dividing line would do well in a common market, and those below would find life increasingly difficult. In many ways this is the sixty-four thousand dollar question, but unfortunately it cannot be answered, and therefore I shall not win the sixty-four thousand dollars! Nor will anybody else, I will hasten to add, because a number of factors make it impossible to solve this problem without a great deal more information about our economy than is ever likely to be available.

Let me indicate the kind of difficulties which I have in mind by means of an example. Suppose the common market becomes established. Tariffs and other trade barriers are reduced all round, and in consequence some British products such as tyres or power-generating machinery will do increasingly well on the Continent; other British industries—say cars and buses—may not be affected much either way, because there may not be any great comparative cost advantage or

disadvantage; and yet other products, such as synthetic fabrics, may feel the pinch of increased competition on the home market. In other words, I am arbitrarily assuming that initially the dividing line lies more or less across the middle of my table. However, it is quite possible that the additional imports which the freeing of trade stimulates exceed the additional exports; a lower price for British tyres on the Continent may lead to smaller increases in exports than the expansion in British imports of rayon goods following the fall in the import price, and likewise for other products. If the British balance of payments was initially in balance,[1] it will now show a deficit, and this deficit will have to be removed by exporting more and/or importing less. In the long run, this can be achieved only by a lowering of money prices in Britain relative to those on the Continent, i.e. by inflation on the Continent, deflation in Britain, or an alteration in the exchange rate. In terms of my table this would mean that those goods doing well already would be doing better still; some of those so far in an indifferent position would begin to do well, and the number of those in acute difficulties would decline. In other words, the group comprising commodities in a relatively strong position would reach further down the table, and that comprising those in a relatively weak position would contract. Needless to add, the opposite process—Britain's balance of payments position becoming a surplus one following the removal of trade barriers, and the dividing line being pushed up in consequence—is equally possible. Thus the reactions on the demand side to the freeing of trade will help to determine at which point in our table we leave the industries which are likely to expand and reach those which are likely to decline.

But it is, of course, impossible to forecast demand reactions; moreover, many other difficulties, no less formidable, are bound to arise. For these reasons, all that one can say is that this division is not likely to occur at either extreme end of the table; in other words, the products at the top of our table—say the first fifteen—certainly look like doing well, and those at the bottom—say the last fifteen—will very probably find themselves in a difficult spot. Therefore, such commodities as tractors, soaps, tyres, plastics, and bicycles will probably be able to expand their output and exports, whilst such items as glass and glassware, pottery, travel goods and, perhaps not surprisingly, watches and clocks, may well be affected adversely. The fate of the thirty commodities in the middle is much less predictable, except that the probability of success declines as one moves down the table. An unsatisfactory outcome, I know—but as I pointed out before, this is not the fault of my particular approach; none of the methods I have mentioned can get around this difficulty.

It only remains for me to point to one other feature of my findings. I mentioned above, in another context, that there is a good deal of difference between the best and the worst performers. In other words, some British products were very much more successful on the Western European market than others. This is not a result one could have predicted with any degree of certainty; it would have been quite possible to find that on the whole there was little to choose between different British goods.

What is the significance of this definite spread of our results? Although this is not the only interpretation one could advance, I would suggest that the marked rate of decline in the standard of performance as one moves down the table at least partly reflects a similarly marked difference in comparative cost conditions as between this country and the Continent. In other words, the figures in the table seem to me to indicate that there is a substantial difference between British industries as regards efficiency as compared with the position on the Continent. If this interpretation is accepted, important conclusions follow with regard to the

[1] Viz. Britain's overall payments vis-a-vis the whole world. Britain's trade with Europe, of course, need not balance either before or after the creation of a common market. Cf. also footnote p. 221.

desirability of the whole common-market venture. The United Kingdom will gain from participation in the common market by specialising on those lines of production she is relatively good at, and giving up other lines in which she is relatively inefficient. Although the size of this gain is determined by a number of factors, amongst them the availability of further economies of scale in Britain and on the Continent, it will to a large extent depend on the difference in comparative costs in Britain as compared with those on the Continent; the larger the difference in comparative costs, the greater the gain will probably be, and vice versa. Therefore, if my findings are correct, and if my interpretation is not mistaken, free trade in Europe may well be able to contribute substantially to a higher standard of living in Britain. It is true that a marked difference in comparative cost conditions also means greater difficulties of adjustment when trade barriers are abolished, but in my view that would be a small price to pay for the lasting benefits that would accrue to Britain from the establishment of a European free-trade area.

BRITISH EXPORTS OF MANUFACTURES TO WESTERN EUROPEAN MARKETS RANKED IN THE ORDER OF THEIR SUCCESS RELATIVE TO THE EXPORTS OF MAIN COMPETITORS.
(1953–1956)

Ranking Order	Commodity (*S.I.T.C. numbers in brackets*)	U.K. Exports: Absolute Levels and Indices of Growth ($m & %)	Britain's Three Strongest Competitors (*Indices of relative level and indices of relative growth*)					
1	Aircraft (734)	40·7 *157·0*	I	10·3 *129·8*	N	8·9 *n.a.*	B/L	3·6 *440·0*
2	Tractors (713)	53·5 *99·5*	G	71·2 *190·8*	I	6·0 *397·0*	S	5·7 *191·0*
3	Power generating (excluding electric) machinery (711)	70·1 *193·0*	G	107·0 *64·2*	I	18·1 *73·2*	N	14·8 *97·4*
4	Cosmetics, soaps and polishes (552)	16·0 *207·4*	G	53·1 *107·4*	F	46·2 *62·8*	N	34·0 *31·1*
5	Rubber tyres and tubes (629–01)	18·3 *112·2*	G	50·0 *198·2*	I	40·8 *119·6*	B/L	40·5 *122·9*
6	Paints and varnishes (533)	13·5 *160·0*	G	111·9 *120·8*	N	34·6 *105·5*	S	11·2 *180·6*
7	Nickel (683)	20·3 *114·3*	G	18·2 *432·0*	F	9·8 *2,950·0*	S	1·0 *942·0*
8	Mineral tar and related crude chemicals (521)	3·8 *103·8*	N	71·5 *156·8*	G	70·8 *107·8*	B/L	46·9 *59·2*
9	Textile machinery and accessories (716–01)	44·7 *97·8*	G	124·6 *179·6*	B/L	21·1 *167·6*	F	19·2 *126·9*
10	Woollen and worsted fabrics (653–02)	55·1 *108·9*	I	82·6 *229·5*	B/L	47·8 *135·4*	N	36·6 *89·1*
11	Plastics (599–01)	26·2 *177·9*	G	149·2 *143·6*	N	28·4 *140·2*	B/L	27·0 *90·0*
12	Road vehicles other than motor (mainly bicycles) (733)	8·8 *109·8*	G	149·9 *180·5*	F	26·4 *94·9*	N	24·3 *65·8*

Ranking Order	Commodity (*S.I.T.C. numbers in brackets*)	U.K. Exports: Absolute Levels and Indices of Growth ($m & %)	Britain's Three Strongest Competitors (*Indices of relative level and indices of relative growth*)					
13	Leather (611)	19·0 *105·3*	F	114·0 *116·9*	G	70·1 *142·1*	B/L	37·4 *99·4*
14	Ships and boats (735)	67·2 *223·4*	G	108·8 *111·5*	S	170·9 *59·5*	N	46·0 *22·6*
15	Articles made of pulp and paper (642)	6·1 *149·2*	G	106·0 *188·2*	N	76·8 *98·7*	F	38·3 *119·2*
16	Railway vehicles (731)	12·8 *191·2*	G	149·1 *56·2*	F	85·0 *146·4*	B/L	34·6 *71·3*
17	Road construction and mining machinery (716–03)	30·0 *108·8*	G	202·1 *134·5*	F	17·5 *115·2*	S	13·3 *144·0*
18	Aluminium (684)	9·2 *145·9*	G	128·2 *91·4*	F	99·4 *39·4*	B/L	38·7 *236·6*
19	Medicinal and pharmaceutical products (541)	16·5 *111·9*	G	125·7 *146·0*	F	75·3 *96·5*	N	46·9 *207·2*
20	Misc. non-ferrous base metals (689)	3·9 *163·7*	B/L	143·8 *126·3*	I	62·1 *175·2*	G	44·3 *114·4*
21	Other industrial machinery (716 *other*)	112·3 *125·1*	G	218·9 *133·3*	S	40·5 *114·0*	F	25·3 *133·3*
22	Cotton yarn and thread, grey, etc. (651–03)	10·9 *52·9*	B/L	137·0 *155·2*	N	43·5 *249·3*	I	25·6 *85·4*
23	Photographic and cinematographic supplies (862)	8·8 *116·4*	B/L	199·4 *94·8*	G	80·6 *176·4*	F	34·5 *120·6*
24	Agricultural machinery and implements (712)	15·7 *99·6*	G	208·2 *190·6*	S	59·9 *123·5*	F	24·8 *80·3*
25	Coal-tar dyes and natural indigo (531)	7·2 *110·2*	G	307·9 *117·0*	F	40·5 *135·2*	I	9·6 *133·2*
26	Cotton yarn and thread, bleached, (651–04)	5·9 *77·0*	B/L	195·0 *164·2*	F	83·3 *n.a.*	I	63·8 *235·5*
27	Yarn of wool and hair (651–02)	22·8 *233·8*	F	264·4 *55·8*	B/L	199·0 *46·3*	G	32·6 *57·7*
28	Buses, trucks and lorries (732–03)	14·4 *97·0*	G	216·7 *199·9*	F	57·0 *89·7*	B/L	45·7 *273·5*
29	Passengers cars (732–01)	83·1 *104·8*	G	217·7 *219·0*	F	55·3 *178·8*	I	38·3 *176·5*
30	Other electrical goods (721 *other*)	82·1 *138·4*	G	220·4 *163·1*	N	108·2 *101·0*	B/L	42·1 *152·0*
31	Electric generators, transformers, etc. (721–01)	18·4 *101·5*	G	316·4 *148·2*	F	40·1 *143·2*	B/L	36·5 *112·6*

Ranking Order	Commodity (*S.I.T.C. numbers in brackets*)	U.K. Exports: Absolute Levels and Indices of Growth ($m & %)	Britain's Three Strongest Competitors (*Indices of relative level and indices of relative growth*)					
32	Copper (682)	38·8 *234·2*	B/L	312·6 *63·0*	G	127·5 *71·3*	S	73·8 *62·6*
33	Office machinery (714)	10·6 *135·9*	G	228·5 *140·4*	I	110·2 *140·3*	S	88·8 *111·9*
34	Inorganic chemicals (511)	25·2 *111·6*	G	246·8 *149·1*	F	111·3 *132·6*	B/L	77·5 *117·4*
35	Cotton fabrics (standard type) (652)	25·5 *67·2*	G	201·1 *172·5*	B/L	122·7 *165·9*	N	80·4 *192·9*
36	Yarn and thread of synthetic fibres (651–06)	8·8 *126·8*	G	204·0 *103·6*	F	180·0 *119·2*	I	133·0 *82·2*
37	Paper and paper board (641)	10·5 *165·5*	N	250·2 *91·8*	G	160·2 *106·7*	B/L	133·0 *81·8*
38	Dyeing and tanning material (532)	1·0 *110·4*	F	185·7 *106·3*	I	135·4 *320·4*	G	109·5 *114·0*
39	Machine tools for working metals (715–01)	15·8 *111·1*	G	454·6 *108·7*	F	49·6 *40·2*	I	37·9 *105·0*
40	Footwear (851)	4·1 *108·5*	I	163·7 *353·9*	G	126·8 *235·0*	N	106·6 *n.a.*
41	Scientific and other instruments (861)	15·0 *141·2*	G	411·4 *127·3*	F	60·6 *93·5*	N	48·4 *274·8*
42	Leather manufactures (612)	1·1 *97·4*	G	246·3 *192·5*	B/L	116·8 *137·0*	N	113·9 *169·6*
43	Organic chemicals (512)	24·6 *80·0*	G	345·0 *174·8*	F	69·1 *208·0*	N	39·3 *330·2*
44	Sanitary, heating and lighting fixtures (812)	5·1 *100·1*	G	294·0 *220·7*	F	87·7 *139·5*	N	79·1 *164·2*
45	Furniture and fixtures (821)	3·0 *129·2*	G	317·1 *240·7*	N	148·7 *68·7*	F	48·7 *88·7*
46	Prefabricated buildings (811)	0·3 *418·9*	G	909·6 *7·1*	S	76·8 *3·5*	N	45·7 *32·0*
47	Glassware (665)	3·3 *147·3*	G	419·4 *141·2*	B/L	170·1 *135·4*	F	154·6 *106·4*
48	Fabrics of jute (653–04)	0·6 *93·6*	G	345·3 *68·4*	B/L	313·0 *190·2*	F	107·5 *156·8*
49	Glass (664)	3·8 *170·6*	B/L	527·0 *96·7*	G	222·9 *97·2*	N	147·5 *85·0*
50	Essential oils (551)	2·0 *177·0*	F	546·5 *78·1*	I	368·9 *67·1*	N	158·9 *n.a.*
51	Fabrics of synthetic fibres (653–05)	7·6 *76·2*	G	511·2 *161·0*	I	191·8 *99·3*	F	135·8 *173·6*
52	Pottery (666)	2·5 *118·3*	G	848·2 *115·3*	F	68·2 *98·1*	N	63·2 *110·9*

Ranking Order	Commodity (*S.I.T.C. numbers in brackets*)	U.K. Exports: Absolute Levels and Indices of Growth ($m & %)	Britain's Three Strongest Competitors (*Indices of relative level and indices of relative growth*)					
53	Tin (687)	7·4	N	459·7	B/L	61·1	G	15·3
		50·7		*362·0*		*605·1*		*79·2*
54	Iron and steel (681)	91·1	B/L	382·3	F	300·8	G	270·8
		90·6		*181·5*		*202·5*		*211·4*
55	Cement (661–02)	1·4	B/L	882·7	G	623·7	F	131·6
		60·3		*142·0*		*116·7*		*117·7*
56	Travel goods (831)	0·6	G	1,434·0	F	125·8	N	69·4
		111·7		*209·8*		*144·7*		*87·4*
57	Lead (685)	1·1	B/L	1,485·0	G	705·7	F	204·5
		97·0		*173·5*		*110·4*		*209·2*
58	Wood and cork manufactures (63)	1·7	S	1,469·0	F	1,222·0	G	855·3
		111·9		*139·8*		*108·9*		*240·4*
59	Watches and clocks (864)	0·6	G	3,944·0	F	354·5	N	28·1
		117·5		*119·9*		*84·1*		*168·1*
60	Zinc (686)	0·7	B/L	4,062·0	G	884·9	N	401·9
		115·6		*106·5*		*116·7*		*124·0*

The indices of growth of British exports (in italics) represent exports in 1956 as a percentage of those in 1953. The indices of relative level (in normal type) represent the absolute level of exports of each item sold by Britain's rivals as a percentage of the absolute level of British exports of the commodities concerned. The indices of relative growth (in italics) represent the indices of growth of exports of each item (exports in 1956 as a percentage of those in 1953) from each of the competitors concerned as a percentage of the index of growth of the corresponding British exports. Cf. also pp. 219 in the text.

Source: O.E.E.C. Foreign Trade Statistics, Series IV, and Annual Statement of the Trade of the United Kingdom.

ASSEMBLY OF CORRESPONDING SOCIETIES[1]

'HUMAN ecology and nature conservation studies' formed the subject of the opening session on Thursday, September 15, in a paper given by Mr. Michael Ó Ruadháin, when research on the productive use of natural resources to cover man's cultural and natural environment and to assess the result of their interaction was discussed. 'So far', said the speaker, 'no arrangements for the systematic study of either human ecology or nature conservation have been made in Ireland', and pointed to 'the opportunity to pioneer in these fields when the proposed new agricultural institute is established', in the Republic of Ireland.

Professor J. Heslop-Harrison followed with a paper on 'Some novel fields for field studies', in which he stated that 'although many of the problems of Irish natural history have attracted world-wide attention, we are lamentably lacking in certain types of information about some of them. Among the neglected aspects is the matter of the reproductive biology of the plants and animals which form the classical elements such as the Lusitanian and North American. We are, for example ignorant of the reproductive capacity in Ireland of one of its most famous plants, the American orchid, *Spiranthes romanzoffiana*, and yet this is a matter directly concerning its distribution, one of the enigmas of the European flora. It appears that its seed-set is low and erratic, seemingly through the failure of pollination; lack of a consistent pollen vector in Europe may in fact be the principal limit to its capacity for spreading. Only recently has the reproductive capacity of *Erica mackaiana*, one of the Lusitanian species in Ireland, been looked into; here again it turns out that the seed output is vanishingly small. In the matter of seed dispersal, where interaction between animal and plant is involved, little or nothing is known about those plants which, whilst common and widespread in England, are astonishingly limited in their Irish ranges. Recently Dr. Boatman has been looking into *Mercurialis perennis*, an excellent example of this kind. He implicates mice as a probable means of dispersal, and points to the absence of the dormouse from Ireland as a factor possibly affecting the capacity of the dog's mercury to spread here. In many plants—particularly woodland herbs—ant dispersal is important; but here again information is totally lacking so far as Ireland is concerned. Truly there is no lack of scope for amateur field study in Ireland; far from being worked out, some of the classical problems of the country's flora and fauna have scarcely yet been defined.'

The Presidential Address was delivered in the afternoon by Professor D. A. Webb, who took as his title, 'The vasculum and the microtome: the relationship between natural history and laboratory biology', (*See p.* 183). Dr. A. E. J. Went followed with an informative paper on 'Fishes in Irish history'.

On Friday, September 6, 'Folk culture and the people' was the title of Mr. George B. Thompson's paper, wherein he discussed the meaning of the term 'Folk' in its broadest sense and its application in compact areas, such as are to be found in Eire, Ulster, Scotland and Wales. The study, at present of a scattered nature, should be centralised to bring before outlying communities its full impact, and there should be local accommodation available for three-dimensional displays, emanating from the central body concerned with the whole, so that a more comprehensive picture could be given. In the considerable discussion which followed a plea was made for towns of historic importance to denote their places of interest by means of on-the-spot labels, linked with the usual information in local guide books.

[1] Report of the proceedings of the Assembly of Corresponding Societies at the Dublin Meeting of the British Association (September 4 to 11, 1957).

Saturday, September 7, was devoted to an excursion ranging over part of Co. Wicklow, under the capable guidance of Mr. A. G. Mason (zoology), Mr. J. P. Brunker (botany) and Miss B. Thompson (geology), who maintained interest throughout with commentaries on features of the area traversed, by a route along the coast, through the Vales of Avoca and Clara and on to Glendalough, where members with archaeological interests found much to occupy their attention. The homeward journey was by way of Powerscourt, past Sugar Loaf mountain, and through the rugged Scalp Gap.

On Monday, September 9, the doyen of Irish field ornithologists, the Rev. P. G. Kennedy, S.J., spoke on 'Bird watching in Dublin Bay', one of the finest and most easily approached observation posts in Ireland. He made especial reference to the North Bull, an island-flat with its vast population of resident, wintering and migratory species, and made a plea for the formation of a ringing station there. The talk was fully illustrated and a useful discussion followed.

Major R. F. Ruttledge then gave an account of 'The migration of birds at the Great Saltee, Co. Wexford', speaking of the work being carried out on the island by a small band of enthusiasts in ringing birds of many species. The paper which was fully illustrated was followed by a very full discussion.

In the afternoon an excursion to Messrs. Arthur Guinness, Son and Company's vast brewery was undertaken. Although demanding considerable activity the effort was well worth while and interest was shown in all the processes seen and explained by the Company's guide. The hospitality extended was greatly appreciated.

Tuesday, September 10, was devoted to a discussion of science in schools, which the Rev. Dr. M. T. Casey opened with an introductory talk on 'Science in our Irish schools'. He maintained that 'science should be taught in all the schools, even for its own sake', and followed with statistics which indicated that such was not yet the case in the Irish Republic. He thought that in a country where agriculture is the main industry, the teaching of biology in schools should take a more prominent place than it does. He would also like to see the formation of a society corresponding to The Science Masters Association in the United Kingdom. In conclusion Dr. Casey referred to the shortage of science teachers and suggested that at home a possible solution would be to seek the assistance of 'priests, nuns and brothers in greater numbers'.

The experiment carried out at the Association meetings in Bristol and Sheffield, of encouraging boys and girls of the Sixth Form to address seniors on a science subject of their own choice, was continued in Dublin by three native speakers and one from Great Britain. Mr. J. D. Gallivan (Newbridge College, Co. Kildare) led with a paper on 'The Rev. Dr. Callan of Maynooth, pioneer of electrical research', the story of a remarkable physicist, 'who used students as volt meters, and invented the induction coil'. Miss V. Poynton (Alexandra College, Dublin) followed with 'Round Dublin in the steps of a marine biologist', with especial reference to Dalkey Island as an ideal study area. Then came Mr. J. R. Tinker (Charterhouse) on 'Bird Reserves', considering them from the ecological, ornithological, and other aspects. The formation of a national park in Ireland was advocated. Finally, Miss C. D. Smyth (Alexandra College, Dublin) spoke on a 'Geological tour in the neighbourhood of Dublin', which proved of high interest. These talks were amply illustrated on the screen and by means of displays.

In the afternoon a very successful lunch took place in the dining rooms at the Zoological Gardens, after which a tour of the Gardens was made under the guidance of the Superintendent. Subsequently the party visited the Botanic Gardens at Glasnevin, where the activities of Section X for the Dublin meeting were concluded.

Representatives attended from thirty-four Societies during the Assembly's meetings in Dublin.

GENERAL TREASURER'S STATEMENT AND ACCOUNT, 1956–57

As was to be expected, costs have risen this year and the deficit has grown with them, to just over £2,000 (neglecting donations). The largest increases have been in postage and printing, travelling and salaries. These are all inevitable; indeed, the last item might be termed inadequate. On the other side, the increases in membership subscriptions and advertisement revenue are welcome. It is not yet known whether the claim which has been made for the recovery of income tax on covenanted subscriptions will be allowed, as it has been in recent years. A number of most generous donations including a further "winding-up" donation from Bristol are most gratefully acknowledged.

In the Report of Council to the General Committee reference is made to discussions which are taking place about the financing of the proposed extended activities of the Association. The effect of inflation on our normal activities is one of the items in the tentative budget that has been prepared. The present accounts should be read in the light of these discussions. When their outcome is known with more certainty, the earliest opportunity will be taken to present a revised financial picture.

M. G. BENNETT,
General Treasurer.

Balance Sheet, 31st March, 1957

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

LIABILITIES

	£ s. d.	£ s. d.
GENERAL PURPOSES :—		
Sundry Creditors	1,362 1 8	
Amounts received in advance for publications	280 1 10	
Membership and Associateship subscriptions in advance	165 5 0	
Amount temporarily held on behalf of Seismological Investigations Committee (Dr. J. E. Crombie's bequest)	500 0 0	
Cash overdrawn at bank	1,439 18 7	
		3,747 7 1
Accumulated Fund		
As per last Account	40,967 16 2	
Less Excess of Expenditure over Income for the year on General Account	1,875 3 3	
		39,092 12 11
Life Membership Fund		
As per last Account	8,662 5 4	
Add Subscriptions received during year	294 0 0	
		8,956 5 4
[*52,489 15 10*]		51,796 5 4
Development Fund		
As per last Account	6,603 13 3	
Add Excess of Income over Expenditure for the year	38 13 9	
[*6,603 13 3*]		6,642 7 0
[*59,093 9 1*]		£58,438 12 4
SPECIAL PURPOSES :—		
Caird Fund		
Capital	9,511 9 11	
Income and Expenditure Account balance as per last Account . 875 18 4		
Add Excess of Income over Expenditure for the year . . . 107 16 0		
	983 14 4	
[*10,387 8 3*]		10,495 4 3
Bernard Hobson Fund (1933)		
Capital	1,093 2 6	
Income and Expenditure Account balance as per last Account . 360 9 11		
Add Excess of Income over Expenditure for the year . . . 32 9 1		
	392 19 0	
[*1,453 12 5*]		1,486 1 6
Leicester and Leicestershire Fund (1933)		
Capital	1,000 0 0	
Income and Expenditure Account balance as per last Account . 216 10 11		
Add Excess of Income over Expenditure for the year . . . 30 15 9		
	247 6 8	
[*1,216 10 11*]		1,247 6 8
Radford Mather Lecture Fund (1936)		
Capital	242 18 0	
Income and Expenditure Account balance as per last Account . 45 13 0		
Add Excess of Income over Expenditure for the year . . . 7 6 8		
	52 19 8	
[*288 11 0*]		295 17 8
[*13,346 2 7*] Carried forward . .		13,524 10 1

ASSETS

	£ s. d.	£ s. d.
GENERAL PURPOSES :—		
Investments as scheduled with Income and Expenditure Account, No. 1	51,372 13 9	
Sundry Debtors	402 1 1	
Cash and stamps in hand	21 10 6	
[*52,489 15 10*]		51,796 5 4
Development Fund		
Investments (see Income and Expenditure Account, No. 2)	6,108 1 5	
Cash at bank	534 5 7	
[*6,603 13 3*]		6,642 7 0
[*59,093 9 1*]		£58,438 12 4
SPECIAL PURPOSES :—		
Caird Fund		
Investments (see Income and Expenditure Account, No. 3)	9,911 9 11	
Cash at bank	583 14 4	
[*10,387 8 3*]		10,495 4 3
Bernard Hobson Fund (1933)		
Investments (see Income and Expenditure Account, No. 5)	1,243 2 6	
Cash at bank	242 19 0	
[*1,453 12 5*]		1,486 1 6
Leicester and Leicestershire Fund (1933)		
Investments (see Income and Expenditure Account, No. 6)	1,000 0 0	
Cash at bank	247 6 8	
[*1,216 10 11*]		1,247 6 8
Radford Mather Lecture Fund (1936)		
Investment (see Income and Expenditure Account, No. 7)	242 18 0	
Cash at bank	52 19 8	
[*288 11 0*]		295 17 8
[*13,346 2 7*] Carried forward . .		13,524 10 1

Balance Sheet, 31st March, 1957 (*continued*)

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

LIABILITIES (*continued*)

	£ s. d.	£ s. d.
[*13,346 2 7*] Brought forward		13,524 10 1
Arthur Haydock Bequest (1945)		
Capital	2,215 12 0	
Income and Expenditure Account balance as per last Account	710 6 2	
Add Excess of Income over Expenditure for the year	13 19 11	
	724 6 1	
[*2,925 18 2*]		2,939 18 1
Corcoran Gift (1946)		
Capital	100 0 0	
Income and Expenditure Account balance as per last Account	19 10 6	
Add Excess of Income over Expenditure for the year	3 5 1	
	22 15 7	
[*119 10 6*]		122 15 7
Science and Industry Committee		
Board of Trade grants	2,660 11 10	
Less unexpended balance refunded	448 8 7	
	2,212 3 3	
Department of Scientific and Industrial Research grants	1,199 5 9	
Less unexpended balance refunded	131 9 8	
	1,067 16 1	
Nuffield Foundation Grant	825 0 0	
	4,104 19 4	
Less Amounts transferred to the Committee	3,950 17 7	
[– – –]		154 1 9
[*16,391 11 3*]		£16,741 5 6

ASSETS (*continued*)

	£ s. d.	£ s. d.
[*13,346 2 7*] Brought forward		13,524 10 1
Arthur Haydock Bequest (1945)		
Investments (see Income and Expenditure Account, No. 8)	2,465 12 0	
Cash at bank	474 6 1	
[*2,925 18 2*]		2,939 18 1
Corcoran Gift (1946)		
Investment (see Income and Expenditure Account, No. 9)	100 0 0	
Cash at bank	22 15 7	
[*119 10 6*]		122 15 7
Science and Industry Committee		
Cash at bank	154 1 9	
[– – –]		154 1 9
[*16,391 11 3*]		£16,741 5 6

We have examined the foregoing Account with the Books and Vouchers and certify the same to be correct. We have also verified the Balance at the Bankers and the Investments.

Approved:
H. J. T. ELLINGHAM
HARRY G. MAULE
Auditors.

W. B. KEEN & CO., *Chartered Accountants*,
Finsbury Circus House, Blomfield St., E.C. 2.

12th June, 1957.

INCOME AND EXPENDITURE ACCOUNTS FOR THE YEAR ENDED 31st MARCH, 1957

No. 1. General Income and Expenditure

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£	s.	d.
	Investments at cost :			
	£8,264 4s. 4d. Consolidated 2½ per cent. Stock	6,401	3	0
	£1,999 0s. 4d. British Gas 3 per cent. Stock, 1990/95	1,520	14	10
	£18,400 0s. 0d. 3 per cent. Savings Bonds, 1965/75	19,098	11	9
	£52 12s. 7d. 3½ per cent. War Stock (Post Office issue)	54	5	2
	£7,704 6s. 2d. 3½ per cent. War Stock	7,840	0	9
	£6,768 15s. 7d. 3½ per cent. Conversion Stock, 1961 or after	5,726	8	11
	£4,184 18s. 2d. 2½ per cent. Treasury Stock, 1975 or after	4,184	18	2
	£1,400 0s. 0d. 4 per cent. Funding Loan Stock, 1960/90	1,622	0	0
	£981 10s. 0d. 4 per cent. Commonwealth of Australia Stock 1955/70	1,000	0	0
	£4,897 18s. 11d. 3 per cent. British Transport Stock, 1978/88	3,824	11	2
	£100 0s. 0d. 3½ per cent. Defence Bonds	100	0	0
	[*Value of stocks at 31/3/56, £38,040 14s. 1d.*] (Value at 31/3/57, £38,025)			
[*51,372 13 9*]		£51,372	13	9

EXPENDITURE

	£	s.	d.	£	s.	d.
Heat, Lighting and Power				124	1	10
Stationery				561	2	8
Overhaul of duplicator and typewriter				47	2	2
Rent				1	0	0
Postages				558	8	7
Telephone				61	2	0
Insurances				12	16	6
Travelling expenses				981	13	0
Audit for 1955-56				115	10	0
Exhibitioners:	95	8	9			
Less Contribution by Liverpool University	50	0	0	45	8	9
Subscription to Parliamentary and Scientific Committee				15	15	0
Subscription to International Union for the Conservation of Nature and Natural Resources				5	0	0
Hire of meeting rooms, equipment, etc.				6	2	6
Alexander Pedler Lecture fee				10	10	0
Lift Inspection and Repairs				18	9	6
Carriage of goods				48	7	10
Reference books, press cuttings, etc.				40	10	0
General expenses				70	18	3
Panels of armorial bearings				14	13	9
Scientific Films at Annual Meeting				69	19	2
Salaries, wages, pensions and National Insurance				4,983	19	2
Printing, etc.—						
"The Advancement of Science"	2,628	5	8			
Preliminary Programme, 1956 1,027 5 7						
Less Contribution by Local Committee 300 0 0						
	727	5	7			
Programme, 1956	803	5	2			
Miscellaneous	394	5	5			
				4,553	1	10
Hospitality				307	1	11
Membership badges				194	15	6
Legal advice				81	4	6
Temporary clerical assistance				84	7	0
Transfer to Toronto University Presentation Fund				43	19	7
[*11,165 16 5*]				£13,057	1	0

INCOME

	£	s.	d.	£	s.	d.
Membership subscriptions				6,809	16	0
Sale of Publications:						
"The Advancement of Science"	800	5	8			
Other items	135	8	3			
				935	13	11
Advertisements in B.A. publications:						
"The Advancement of Science"	616	7	0			
Preliminary Programme, 1956	418	10	9			
Programme, 1956	634	18	0			
	1,669	15	9			
Less final payment to former Agents	126	5	0			
				1,543	10	9
Income Tax recovered to 31st March, 1956:						
On Interest and Dividends (Claim of £572 13s. 8d. on covenanted subscriptions not yet allowed)				87	1	8
Interest on Investments				1,598	3	0
Donations received:						
from Local Committee for the Bristol Meeting, 1955	463	0	0			
Less Amount taken into account last year	398	14	2			
	64	5	10			
Other donations	75	6	3			
				139	12	1
Charges for administration of Special Funds				68	0	4
[*11,118 0 6*]				11,181	17	9
Balance, being excess of Expenditure over Income for the year				1,875	3	3
[*47 15 11*]						
[*11,165 16 5*]				£13,057	1	0

No. 2. Development Fund

An Appeal for a Development Fund to be used under the direction of the Council, was made at the Annual Meeting at Dundee in 1947. The fund is still open.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investments at cost :	
	£2,745 19s. 0d. London County 2¾ per cent. Consolidated Stock, 1960/70	2,750 0 0
	£3,387 14s. 10d. Savings 3 per cent. Stock, 1965/75	3,028 7 0
	£292 15s. 3d. Consolidated 2½ per cent. Stock	200 0 0
	£175 0s. 0d. 3½ per cent. War Stock	129 14 5
	[*Value of stocks at 31/3/56, £4,815 0s. 4d.*] (Value at 31/3/57, £4,957)	
[*5,978 7 0*]		£6,108 1 5
	Cash at bank	£534 5 7

EXPENDITURE	£ s. d.		INCOME	£ s. d.	
Membership index cards, etc.	36 17 4		Interest	184 9 2	
Badge registers	15 19 2				
Typewriter	62 10 0				
Typists' Desks	12 0 0				
Administration charge	18 8 11				
[*18 8 11*]	145 15 5				
Balance, being excess of Income over Expenditure for the year	38 13 9				
[*166 0 3*]					
[*184 9 2*]	£184 9 2		[*184 9 2*]		£184 9 2

No. 3. Caird Fund

The unconditional gift of Sir James Caird, in 1912, administered by the Council in accordance with recommendations adopted by the General Committee in 1913.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investments at cost :	
	£2,904 11s. 8d. British Gas 3 per cent. Stock, 1990/95	2,209 13 0
	£2,716 16s. 6d. 3½ per cent. War Stock	2,516 15 5
	£4,282 18s. 9d. 3 per cent. British Transport Stock, 1978/88	4,785 1 6
	£585 10s. 6d. Consolidated 2½ per cent. Stock	400 0 0
	[*Value of stocks at 31/3/56, £7,276 8s. 0d.*] (Value at 31/3/57, £7,035)	
[*9,911 9 11*]		£9,911 9 11
	Cash at bank	£583 14 4

EXPENDITURE	£ s. d.	£ s. d.	INCOME	£ s. d.	
Rent of tables for 1957 at Biological Stations:			Interest	270 14 8	
Naples Zoological Station	50 0 0		Income Tax recovered	54 12 0	
Freshwater Biological Association, Windermere	50 0 0				
Marine Biological Association, Plymouth	50 0 0				
		150 0 0			
Grants to Research Committees:					
Inventaria Archaeologica	20 0 0				
Glossary of Geographical Terms	5 0 0				
Ainu of Japan	10 0 0				
		35 0 0			
Administration charge		32 10 8			
[*192 17 1*]		217 10 8			
Balance, being excess of Income over Expenditure for the year		107 16 0			
[*135 13 11*]					
[*328 11 0*]		£325 6 8	[*328 11 0*]		£325 6 8
Grant authorised, not yet drawn :—					
Derbyshire Caves	10 0 0				
[*15 0 0*]	£10 0 0				

No. 4. Toronto University Presentation Fund

A fund voluntarily subscribed by members present at the Toronto Meeting in 1924. In June 1954 the Council, with the approval of the University of Toronto, decided to expend the fund on the purchase of a Presidential Badge to be called the Toronto Badge, instead of providing two bronze medals annually together with books for presentation to selected students.

EXPENDITURE	£	s.	d.	INCOME	£	s.	d.
Cost of the Toronto Badge	175	0	0	Interest	6	2	6
Case, photograph, etc.	14	11	0	Transfer of balance of Fund as at 1st April, 1956	188	18	1
	189	11	0	Transfer from General Income and Expenditure Account	43	19	7
Administration charge	12	3					
Loss on Sale of Investment	48	16	11				
	£239	0	2		£239	0	2

No. 5. Bernard Hobson Fund

The bequest of Mr. Bernard Hobson, 1933; the income to be applied to the promotion of geological research; administered by the Council.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

	Investments at cost:	£	s.	d.
	£50 0s. 0d. 4 per cent. Victory Bonds	55	10	5
	£601 9s. 0d. 2½ per cent. Treasury Stock, 1975 or after	601	9	0
	£416 0s. 11d. 3½ per cent. War Stock	436	3	1
	£178 16s. 4d. Consolidated 2½ per cent. Stock	150	0	0
	[*Value of stocks at 31/3/56, £769 9s. 9d.*] (Value at 31/3/57, £770)			
[*1,243 2 6*]		£1,243	2	6
	Cash at bank	£242	19	0

EXPENDITURE	£	s.	d.	INCOME	£	s.	d.
Administration charge [*3 12 1*]	3	12	1	Interest	36	1	2
Grant [*20 0 0*]	–	–	–				
Balance, being excess of Income over Expenditure for the year [*12 9 1*]	32	9	1				
[*36 1 2*]	£36	1	2	[*36 1 2*]	£36	1	2
Grant authorised, not yet drawn:— Critical Geological Sections	30	0	0				
[*30 0 0*]	£30	0	0				

No. 6. Leicester and Leicestershire Fund, 1933

The unexpended balance of the local fund for the Leicester Meeting in 1933, presented to the Association, the interest to be used in assisting by scholarships or otherwise students working for the advancement of science; administered by the Council.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

	Investments at cost:	£	s.	d.
	£487 2s. 11d. 3½ per cent. Conversion Stock	500	0	0
	£490 5s. 11d. 3½ per cent. War Stock	500	0	0
	[*Value of stocks at 31/3/56, £708 13s. 8d.*] (Value at 31/3/57, £713)			
[*1,000 0 0*]		£1,000	0	0
	Cash at bank	£247	6	8

EXPENDITURE	£	s.	d.	INCOME	£	s.	d.
Administration charge [*3 8 5*]	3	8	5	Interest	34	4	2
Balance, being excess of Income over Expenditure for the year [*30 15 9*]	30	15	9				
[*34 4 2*]	£34	4	2	[*34 4 2*]	£34	4	2

No. 7. Radford Mather Lecture Fund

A gift of £250 received from Mr. G. Radford Mather in 1936 to establish a Fund, the income therefrom to be devoted to meeting the expense of triennial Lectures on Recent Advances in Science and their relation to the Welfare of the Community.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investment at cost :	
	£271 14s. 6d. Savings 3 per cent. Stock, 1965/75	242 18 0
	[*Value of stock at 31/3/56, £205 3s. 0d.*] (Value at 31/3/57, £205)	
[*242 18 0*]		£242 18 0
	Cash at bank	£52 19 8

EXPENDITURE	£ s. d.	INCOME	£ s. d.
Administration charge [– *16 4*]	16 4	Interest	8 3 0
Balance, being excess of Income over Expenditure for the year [*7 6 8*]	7 6 8		
[*8 3 0*]	£8 3 0	[*8 3 0*]	£8 3 0

No. 8. Arthur Haydock Bequest

A bequest received in 1945 "for the purpose of original investigation of problems relating to either or both of Geology or Botany as may be determined by the governing body of the British Association."

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investments at cost :	
	£2,090 4s. 0d. 3½ per cent. Conversion Stock	2,215 12 0
	£362 6s. 3d. Consolidated 2½ per cent. Stock	250 0 0
	[*Value of stocks at 31/3/56, £1,688 6s. 7d.*] (Value at 31/3/57, £1,709)	
[*2,465 12 0*]		£2,465 12 0
	Cash at bank	£474 6 1

EXPENDITURE	£ s. d.	INCOME	£ s. d.
Grant to Coal Ball Flora Research Committee [– – –]	60 0 0	Interest	82 4 4
Administration charge [*8 4 5*]	8 4 5		
Balance, being excess of Income over Expenditure for the year [*73 19 11*]	13 19 11		
[*82 4 4*]	£82 4 4	[*82 4 4*]	£82 4 4

No. 9. Corcoran Gift

A gift of £100 received in 1946 for research in memory of Miss J. R. Corcoran.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investment at cost:	
	£144 18s. 6d. Consolidated 2½ per cent. Stock	100 0 0
	[*Value of stock at 31/3/56, £77 10s. 9d.*] (Value at 31/3/57, £77)	
[*100 0 0*]		£100 0 0
	Cash at Bank	£22 15 7

EXPENDITURE	£ s. d.	INCOME	£ s. d.
Administration charge [– *7 3*]	7 3	Interest	3 12 4
Balance, being excess of Income over Expenditure for the year [*3 5 1*]	3 5 1		
[*3 12 4*]	£3 12 4	[*3 12 4*]	£3 12 4

OFFICERS FOR THE DUBLIN MEETING

September 4—11, 1957

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DR. A. K. MILLS

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Accommodation and Excursions: MR. E. P. KEARNEY
Publicity: MR. J. J. BYRNE
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SEISMOLOGICAL INVESTIGATIONS

SIXTY-SECOND ANNUAL REPORT of the COMMITTEE on Seismological Investigations. (Dr. R. STONELEY, F.R.S., *Chairman*, Mr. E. TILLOTSON, *Secretary*, Mr. E. F. BAXTER, Miss E. F. BELLAMY, Prof. P. G. H. BOSWELL, O.B.E., F.R.S., Mr. B. C. BROWNE, Sir E. C. BULLARD, F.R.S., Dr. K. F. CHACKETT, Dr. G. E. R. DEACON, C.B.E., F.R.S., Dr. A. T. J. DOLLAR, Dr. A. E. M. GEDDES, O.B.E., Prof. G. R. GOLDSBROUGH, C.B.E., F.R.S., Dr. M. N. HILL, Mr. J. S. HUGHES, Prof. Sir H. JEFFREYS, F.R.S., Dr. E. R. LAPWOOD, Rev. C. REY, S.J., Dr. G. D. ROBINSON, Dr. N. A. ROUTLEDGE, Mr. H. V. SHAW, and Sir FRANK E. SMITH, G.C.B., G.B.E., F.R.S.)

THE GRAY-MILNE FUND

A new driving clock for the Committee's Milne-Shaw seismograph at Hermanus has been purchased from Messrs. Hilger and Watts. This replacement has been delivered at South Africa House. An application has been received from Dr. M. N. Hill for a sum of about £500 for the purchase of specific items of scientific equipment for the Crombie Seismological Laboratory. It is proposed to accede to this request, and to pay it either wholly or in part from the Crombie Bequest. The £500 balance of the Crombie Bequest remains deposited with the Treasurer of the Association; the sum of £400 is still invested in Defence Bonds.

GRAY-MILNE FUND

Receipts

	£	s.	d.
Balance, July 31, 1956	644	2	8
Trust Income	80	14	10
Interest from Defence Bonds	10	0	0
Sale of Publications	1	0	5
	735	17	11

Payments

	£	s.	d.
Driving clock for seismograph at Hermanus	26	9	0
Balance at Bank, July 31, 1957	709	8	11
	735	17	11

INSTRUMENTS

There has been no change in the location of the instruments belonging to the Committee during the past year. The instruments are located as follows:

No. 1. Science Museum, South Kensington.
,, 3. Edinburgh.
,, 4. Downe, Kent (in storage).
,, 6. Hermanus, South Africa.
,, 27. Perth, Western Australia.
,, 63. Suva, Fiji.
Jagger Shock Recorder at Fort Augustus.

THE INTERNATIONAL SEISMOLOGICAL SUMMARY

By J. S. Hughes

The preparation of the Seismological Summary continues at Kew Observatory by the courtesy of H.M. Meteorological Office, and active assistance from the superintendent, Dr. G. D. Robinson. Including myself as chief assistant, the regular staff consists of three. Mrs. Sanders has been in charge of clerical work for eight years and continues in that capacity, also assisting with computing and checking of copy when required. Mr. J. Wavish has been technical assistant now for two years, and we also have part-time help from Mr. Biddle and Mrs. Sykes. On the whole we are an assistant short, but it is difficult to get helpers who can be relied on and who will continue in the routine work, and the dependence on part-time assistance might be a solution to the problem of making progress.

The 1949 copy is in the press, but there has been a great increase of material to be dealt with. The large numbers of stations now appearing in America, U.S.S.R., Southern Europe, together with the increase in seismicity, notably during July, August and again in December, has made progress slower. This increase in weight of the work continues into subsequent years. Multiplication of stations in close proximity has taken place rather rapidly and adds much to computing and clerical work without improving or assisting accuracy. Twelve stations reporting from about the same place do not say any more than two or three would, always assuming the observatories are of high quality.

The storing of undistributed stock of the I.S.S. is a source of some anxiety. At present this has been placed in cases in a basement at the observatory where it is hoped that the heat from the centralised unit will prevent damage from damp. The stock is increasing, and as the size of the volume increases so the necessary space for store required will increase at a faster rate.

THE DEPARTMENT OF GEODESY AND GEOPHYSICS, CAMBRIDGE UNIVERSITY

Director: Mr. B. C. Browne

Report from Dr. R. Stoneley, F.R.S.

Theoretical. Dr. S. D. Chopra, working under the direction of Dr. E. R. Lapwood, has been investigating the problem of a source at a point in an internal stratum. He has taken his general solution to a point where insertion of numerical data can give results to be compared with experiments, and has also proposed a method by which the amplitudes of the various body and interface waves can be calculated for more complicated models.

Dr. R. Stoneley has investigated the variation of amplitude with depth in Love waves propagated in a two-layer continent. The distribution of potential energy and kinetic energy in the layers has been worked out for two special cases: (i) long waves, (ii) short waves. This paper is being published in the forthcoming Gutenberg Presentation Volume.

The paper on Turbidity Currents mentioned in last year's report has been published in the Vening Meinesz Jubilee Volume. The book also contains an appreciation by Dr. Stoneley of Dr. Vening Meinesz's services to international co-operation in geodesy and geophysics, with particular reference to the part played in enlarging the scope of the international Association of Seismology to include physics of the earth's interior, and in bringing about the formation of the European Seismological Commission.

Experimental. Thanks to a generous grant from the Atomic Energy Authority the Crombie Seismological Laboratory has been completed and equipped on a

much larger scale than was originally contemplated. Three Benioff instruments of period I sec., together with the two horizontal long-period Hill seismographs, have been installed in the underground chamber. The recordings are made by land-line in the Crombie Laboratory some yards away, so that the vault need be visited only when adjustments are needed to the seismographs. The recordings from the long-period instruments are made on wax-coated paper by a heated stylus in daylight, and, by connecting a condenser across the output, the ground-velocity in addition to the ground displacement is recorded. The arrival of the waves from the Derbyshire earthquake was watched by Mr. Adams while these two seismographs were set up experimentally in the cellar at Madingley Rise. These instruments have also recorded long-period surface waves of period up to 250 seconds from large earthquakes. Mr. R. D. Adams is investigating these waves, the propagation of which is controlled by the mantle of the Earth. Dr. Norman A. Routledge, Fellow of King's College, Cambridge, who has been appointed as Seismologist in the department, has taken the major share of the work of organising the Crombie Laboratory and installing the instruments.

International Geophysical Year. Dr. Stoneley, as National Correspondent for Seismology on the British National Committee for the I.G.Y., has been responsible for making arrangements for the British participation in the seismological programme. The British stations will be sending monthly bulletins of station readings and of microseismic data direct to the three world data centres; the seismographs at Bidston have been converted to act as tilt-meters so as to take part in the world programme of earth-tilt measurements. The seismological stations in the West Indies will also be co-operating. In addition, special researches on the long-wave phase have been undertaken at Cambridge.

Willmore seismographs installed at the Royal Society's base at Halley Bay in Antarctica commenced recording at the beginning of the I.G.Y., as did also the Falkland Islands Dependencies Survey Station at Argentine Islands. Both this and the other F.I.D.S. station (Port Stanley) are equipped with Willmore seismographs, and it is expected that Port Stanley will be recording during the I.G.Y. The data from these three Antarctic stations will be sent to the National Centre at Cambridge, from which the bulletins will be despatched to the three world data centres. It is a pleasure to record the generous co-operation of the American I.G.Y. in undertaking to send also to Halley Bay the information about epicentres that is being sent regularly to American stations in the Antarctic.

DURHAM UNIVERSITY SEISMOLOGICAL OBSERVATORY

By Mr. E. F. Baxter

A Wilson-Lamison vertical seismometer coupled to an American G.E. galvanometer of free period 3·4 sec. and recording on a Milne-Shaw type recording apparatus running at 16 mm./min. has been working in a constant-temperature below-ground chamber since October 1. The Milne-Shaw horizontal component instruments have been operating in this chamber also from October 1.

The Midlands Earthquake of February 11, 15 *hrs.*

A least squares determination of the epicentre and origin time from the Pn readings of Cambridge, Kew, Durham and Rathfarnham gave 52° 50′ N., 01° 21′ W., H 15.43.00.

Using all the readings as set out below, this corrects to 52° 50′ N., 01° 20′ W., H 15.43.00. The differences in the two solutions are small: to the nearest minute there is unit difference. There was an after-shock on February 12: H 23.59.42. The data of the quake of 1956 January 10—08 hrs., 52° 45′ N., 01° 30′ W., to the nearest five minutes—would seem to be insufficient to determine if it was a fore

shock from the same epicentre. As stated in the 1956 report the readings of this earthquake do not allow of a very precise epicentral determination.

1957, FEBRUARY 11, 15 HRS. MIDLANDS EARTHQUAKE

Epicentre 52° 50′ N., 01° 20′ W., H 15H. 43M. 00S.

Station	*Readings G.M.T.*	*O–C (sec.)*	*Epicentral distance*
Cambridge	Pn 15.43.19	− 1	58′
	Sg 15.43.33	+ 1	
Kew	iPnNZ 15.43.26·5	− 1	1° 30′
	iPgNZ 15.43.31	+ 1	
	iSnNEZ 15.43.46	− 3	
	iSgNE 15.43.51	0	
	iE 15.44.00		
	MNEZ 15.44·1		
Durham	ePnZ 15.43.35	+ 1	1° 56′
	PgNEZ 15.43.37	− 2	
	SnNEZ 15.44.02	+ 2	
Rathfarnham	iPnZ 15.43.47·5	− 1	3° 01′
Jersey	e 15.44.38		3° 42′
	iSn 15.44.40	− 5	
	e 15.44.51		
	iSg 15.44.57	− 5	
De Bilt	ePg 15.44.24	+ 3	4° 03′
	e 15.45.18		
Aberdeen	ePnNE 15.45.08	+59	4° 22′
	iSnNE 15.45.58	+57	
Paris	iP 15.44.11	0	4° 41′
Bensberg	ePn 15.44.22	− 1	5° 35′
	ePg 15.44.45	− 6	
	e 15.45.00		
	eiSn 15.45.20·5	−12	
	ei 15.45.36		
	eiSg 15.45.57	− 7	
Hamburg	ePn 15.44.42	+ 2	6° 50′
	eZ 15.44.58		
	ePgZ 15.45.17·5	+ 1	
	eZ 15.45.56·9		
	iSnZ 15.46.02·3	− 1	
Strasbourg	ePn 15.44.44·5	0	7° 10′
	iPg 15.45.17	− 6	
	i 15.45.58·5		
	i 15.46.15		
	eSg 15.46.43	−14	
	eSg 15.46.48	− 9	
Clermont-Ferrand	iPn 15.44.52	0	7° 39′
	iPg 15.45.31·5	− 1	
	i 15.46.04·5		
Stuttgart	iPn 15.44.52·7	0	7° 48′
	e 15.44.56		
	eSn 15.46.17	−11	
	e 15.46.31		
	e 15.46.45		
	eSg 15.47.00	−18	
	eSg 15.47.14	− 4	

Station	*Readings G.M.T.*	*O–C (sec.)*	*Epicentral distance*
Prague	eP 15.45.27	— 2	10° 13′
	eiS 15.47.23	— 2	
Uppsala	iPn 15.45.57	— 5	12° 37′
	iSn 15.48.10	—13	
	iSS 15.48.24		
	iSSS 15.48.54		
Kiruna	iPn 15.47.09	— 6	18° 19′
	iSS 15.51.08		
College (Alaska)	eP 15.53.05	0	59° 49′
Hungry Horse (Montana)	eP 15.53.34	— 2	64° 09′
REPETITION, FEBRUARY 12, H. 23H. 59M. 42S.			
	(February 13)		
Cambridge	Sg 00.00.15	+ 1	58′
Kew	iPn 00.00.08	— 2	1° 30′
	eSn 00.00.28	+ 1	
	e 00.00.44		
Durham	ePnZ 00.00.19	+ 3	1° 56′
	eE 00.00.40		
	eSnNEZ 00.00.45	+ 3	
Strasbourg	eSnZ 00.02.52	+ 1	7° 10′
	eSgZ 00.03.43	— 4	
Stuttgart	ePnZ 00.01.33	— 2	7° 48′
	eSn 00.03.02	+ 4	
	eSg 00.03.52	+ 4	
	eSg 00.03.55	+ 1	

The macroseismic effects of the Midlands earthquake of February 11, 1957, were described by Dr. A. T. J. Dollar in *Nature*, vol. 179, no. 4558, of March 9, 1957, pp. 507–10, and *Proc. Geol. Soc. London*, no. 1553, 28, August 1957, pp. 113–14. Mr. G. Lees, of the Natural Science Department of the Derby and District College of Technology, noted particularly in the *East Midlands Geographer* of June 1957, the operation of seventeen electrical relays at five power stations in the East Midlands Division of the Central Electricity Authority by the earthquake. He has investigated this matter in some detail and it is hoped that the results will be published elsewhere later.

NATIONAL INSTITUTE OF OCEANOGRAPHY

Director: Dr. G. E. R. Deacon, C.B.E., F.R.S.

M. J. Tucker has corrected one or two minor faults in the electronic microseismograph mentioned in the last report, and it has now been operating satisfactorily for some months. The prototype instrument measures only one component and is thus not very useful for microseismic research, but a properly engineered instrument measuring both horizontal components is being designed. It is hoped this will be followed by a vertical-component instrument, making a complete and semi-portable microseismic installation.

J. and Mollie Darbyshire have prepared refraction diagrams for the British Isles similar to those drawn for Bermuda. They include 6-sec. microseisms approaching from SW., WSW., W., WNW. and NW. directions, and of 4-sec. and 8-sec. waves approaching from the W. direction. The diagrams showed that the deviations varied from 7° for WSW. to 26° for WNW., and that the intensity of microseisms approaching from the W. direction were much reduced. This was confirmed by

examination of the variation of the intensity of the vertical component of microseisms due to sixteen moving storms during the period 1945–53 which were on a westerly bearing to the British Isles at one stage in their track. The work has been published in *Mon. Not. R. Astr. Soc., geophys. suppl.*

H. M. Iyer is studying the direction of arrival of microseisms, using the correlation technique put forward by Darbyshire in 1954 and using seismograph records from Kew Observatory. It was found that the correlation coefficient between the two horizontal components, which are a mixture of Love and Rayleigh waves, was in general a very small quantity and as such could not be used for accurate bearing estimation. A modified theory involving only the correlation between the Rayleigh waves in the vertical and horizontal components was developed. A preliminary study of microseisms generated by four storms in the Atlantic gives very interesting results:

(1) There is a high Love/Rayleigh ratio which is dependent on the direction of arrival of microseisms.
(2) A second source of microseisms, probably near the coast, can be detected as the storm gets older, with a general increase in the period and intensity of the recorded microseisms.
(3) In general a narrow band of microseismic frequencies around the spectral peak seems to follow the storm centre more closely than the total spectrum.

The physics of the problem is being studied in detail using instrumental rather than classical methods of analysis, taking frequent and long samples of microseismic records obtained during the passage of Atlantic storms. Three fast storms of 1949, 1951 and 1956 are chosen for this study and efforts are made to obtain records from as many relevant stations as possible. It is hoped that this analysis will give an idea regarding the intricate nature of the microseismic source, the structure of the waves, and the usefulness of the information from a meteorological and oceanographic point of view.

NUTATION AND THE VARIATION OF LATITUDE

By Prof. Sir Harold Jeffreys, F.R.S. and R. O. Vicente

It is known that elasticity tends to lengthen the period of the free (14-monthly) variation of latitude and that fluidity of the core shortens it. In addition it has been known for some time that the amplitude of the 19-yearly nutation is a little less than that calculated for a rigid earth, and that a reduction is produced by fluidity of the core, but partly compensated by elasticity of the shell. In two papers Jeffreys and Vicente have used modern values of the elastic properties of the shell, the statical theory of which was given by H. Takeuchi. Two models are used for the core. In the first paper it is treated as homogeneous and incompressible, with an extra particle at the centre. In the second a quadratic law of density is adopted, the variation of density being supposed wholly due to compression. In both, the constants are adjusted to give the correct mass and moment of inertia of the core. The correct values of the observable quantities should lie about midway between those given by the two models.

It is found that the free period, in the absence of the ocean, would be about 390 days, but that the ocean would probably increase this to about 430 days. The 19-yearly nutation in obliquity also comes out in good agreement with observation. The effect on the nutation in longitude, however, is in disagreement with the result of Fedorov's discussion, which is so far the only one that determines it separately.

The bodily tide numbers h, k, l have been computed. For semi-diurnal and long-period tides they have the same values, but they differ for different diurnal tides. It is hoped that observations of the bodily tides will soon be able to test the values predicted.

PROPAGATION OF A PULSE IN A LIQUID SPHERE

By Prof. Sir Harold Jeffreys, F.R.S., and Dr. E. R. Lapwood

Analysis of seismic records suggested that the form of a pulse differs systematically according as the time of travel is a minimum for all variations of the path or a minimum for some and a maximum for others. Several previous theoretical papers have shown that this is true for analogous problems, but the effect of reflexion at a spherical boundary has not been treated directly. In this paper the problem is solved for a liquid sphere. It is found that if P is a sharp pulse, pP would be one too, but PP would be a large diffuse movement about the theoretical time.

WAVES IN A MEDIUM WITH CONTINUOUS VARIATION OF PROPERTIES

By Prof. Sir Harold Jeffreys, F.R.S.

Asymptotic solutions of the equations of wave propagation are used to discuss internal reflexion, analogous to mirage, and propagation in an internal layer of low velocity. In both cases in the absence of a free surface, the P, SV and SH types of movement would remain nearly independent. Internal reflexion produces a phase shift of $\frac{1}{2}\pi$. Propagation in an internal layer is possible for all types. In the presence of a free surface, however, special conditions are required if the movement at the surface is not to be very small compared with that in the layer; and though SV and SH can travel to any distance, P will suffer a gradual attenuation with distance on account of conversion into SV at the free surface.

TIDAL FRICTION IN SMALL BODIES

By Prof. Sir Harold Jeffreys, F.R.S.

The damping of the variation of latitude seems most likely to be due to elastic afterworking in the Earth's shell, which would make the effective rigidity less for long-period than for short-period disturbances. Two solutions are available, according as the time needed to establish the long-period rigidity is of the order of a week or a year. These are tested by application to the damping of the rotations of the Moon and Mercury and the librations of the Moon. It is found that the longer time-scale leads to considerable difficulties in accounting for the facts that these bodies keep a constant face to their primaries and that the librations are small. The shorter scale explains them quite simply.

During the year Dr. A. E. M. Geddes, O.B.E., has written two papers on microseisms. One paper has been accepted for publication elsewhere, and the other is: 'Note on large Microseisms recorded at Aberdeen on 1954 December 9', *M.N.R.A.S. Geophysical Supplement*, vol. 7, no. 5, 1957, pp. 219–27.

Ir is desired to put on record the importance which the Committee attaches to the seismological station at Rathfarnham. This is now especially so when considering epicentres in the United Kingdom since the seismographs at Bidston have been adapted to another purpose.

EDINBURGH SEISMOGRAMS

The secretary has now read these seismograms to the end of 1955.

REPORT OF COUNCIL TO THE GENERAL COMMITTEE, 1956–57

(Received and adopted by the General Committee on September 4, 1957)

Obituary

1. Since the last Report the Council has mourned the passing of Professor Winifred Cullis, a well-beloved and long-standing member of the Association and a former member of Council, and of Sir John Simonsen, Honorary Auditor, past member of Council and past President of Section B (Chemistry). The Council has suffered further loss by the death of the following office bearers and supporters:

Mrs. F. D. Bateman
L. Bainbridge Bell, M.C.
P. Culverwell Brown
Prof. R. N. Rudmose Brown
Dr. E. H. Cartwright
Prof. F. G. Donnan, C.B.E., F.R.S.
W. N. Edwards
A. Gepp
T. C. F. Hall
T. C. Hart
Dame Caroline Haslett, D.B.E.
Miss C. A. Jacobsen
Arthur Jaffé, O.B.E.
F. S. Lowe
P. H. Oakley
T. Harold Reade
Dr. R. B. Rees
Dr. M. M. Richardson
H. N. Ridley, C.M.G., F.R.S.
Miss J. M. R. Robb, J.P.
Sir David Russell
T. Sampson
Prof. Sir Francis E. Simon, C.B.E. F.R.S.
Sir W. Wright Smith, F.R.S.
Dr. J. Stewart
Dr. R. A. Taylor
Col. C. E. Temperley
Dr. J. Wishart

Relations with other Institutions

2. The Association has maintained cordial relations with Institutions at home through its official representatives and in other ways. There have been no changes in the standing representation of the Association in the work of other bodies. Dr. W. E. Swinton has been appointed to represent the Association on the Council of the National Book League, and Dame Kathleen Lonsdale on the Committee of the International Congress of the International Union of Crystallography which is to meet in Cambridge in 1960. The President and General Officers met Mr. Percy Cudlipp, Editor of the *New Scientist*, a non-specialist weekly scientific journal published for the first time in November 1956, and assured him of the Association's interest in and goodwill towards what was in their view a significant contribution to the all-important field of dissemination of scientific knowledge to the public.

3. The Council report that on the occasion of the Dublin Meeting they have once again offered complimentary memberships to the Overseas Science Students Association.

4. Having no meeting rooms of its own, the Association is again indebted to the Royal Society for providing accommodation for Council and Committee meetings held during the year. The Council also wish to record their appreciation of the generosity of the Rector of the Imperial College of Science and Technology in making possible a meeting in the College of Officers, Presidents of Sections and Recorders; and of the Master of Birkbeck College for putting at the disposal of the Association on January 4, 1957, meeting rooms and refectory on the occasion of the installation of the President for 1957, and of combined meetings of all the Section Committees.

5. In the international field the Council has appointed the following official representatives:

The 18th International Geographical Congress, Rio de Janeiro, Professor R. Ogilvie Buchanan.

The Annual Meeting of the Ceylon Association for the Advancement of Science, November 22–24, 1956, Sir Harry Champion, C.I.E.

The 44th Session of the Indian Science Congress in Calcutta, January 14–20, 1957, Sir Harold Spencer Jones and Dr. N. C. Wright. Dr Wright conveyed, at the same time, a message of congratulation to the Vice-Chancellor of the University of Calcutta, which held its Centenary Celebrations from January 20 to 25, 1957.

The 9th Annual Meeting all Pakistan Science Conference, Peshawar, March 11–18, 1957, Sir Harold Hartley and Dr. W. Campbell Smith.

The 76th Annual Meeting of the French Association for the Advancement of Science, Perigueux, July 16–21, 1957, Dr. George Taylor.

6. Relations with institutions and colleagues overseas have also been maintained by correspondence and in other ways. The Council were deeply distressed to learn of the sudden and untimely death of Dr. Bashir Ahmad, General Secretary of the Pakistan Association for the Advancement of Science, during the course of the 9th Annual All Pakistan Science Conference. Dr. Bashir Ahmad was a familiar and welcome figure at the British Association's meetings and will be greatly missed not only in his own country but also by his many friends and colleagues in this country. The Secretary has had conversations with Dr. Dael Wolfle, Secretary of the American Association for the Advancement of Science, and with officers of the Australian and New Zealand Association. A number of distinguished overseas scientists, including representatives of sister Associations, have been invited to attend the Dublin Meeting and the Council is pleased to report that among them will be Dr. Paul B. Sears, retiring President of the American Association, and Professor A. E. H. Bleksley, President Elect of the South African Association. The Council is indebted to the British Council for their generosity in initiating and making possible a scheme—now in operation—for an exchange of delegates with the Ceylon Association for the Advancement of Science.

UNESCO

7. The Council received an invitation to make nominations for the award of the Kalinga Prize for 1957, the purpose of which is to offer recognition to leading interpreters of science and to strengthen the links between India and scientists of other nations, but decided to make no nomination.

FINANCE

8. The General Treasurer has kept the Council informed of the state of the Association's finances, and his Statement and Account for the financial year ending on March 31, 1957, will be submitted to the General Committee. Improvements in the income from membership subscriptions and an increase in advertising revenue have been more than offset by increases in a number of items which include printing, travelling claims, stationery and postage. One change has been made which will result in an annual saving: this is the substitution of a combined cardboard badge and membership ticket for the ticket and metal badge hitherto supplied to members. The new badge has been introduced for the Dublin Meeting.

9. The Committee appointed by the Council to consider the future financial needs of the Association has kept in close touch with the Functions Committee and has discussed informally with a number of prominent industrialists certain proposals arising out of the Second Report on the Functions of the Association (see para. 12 below), together with the estimated cost of implementing these proposals.

10. It is hoped to make a full report on these proposals to the General Committee at Dublin.

Functions of the Association

11. At the Sheffield Meeting the General Committee received and considered a first Report on the Functions of the Association prepared at the request of the Council by the Committee of the Division for the Social and International Relations of Science under the chairmanship of Sir Ben Lockspeiser. The text of this Report was later published in the December 1956 issue of *The Advancement of Science* (Volume XIII, No. 51, page 205). Following discussions between the General Officers and Officers of Sections, the Council appointed the following as a Programme Advisory Committee: The President and General Officers, Professor H. D. Kay, Mr. Ritchie Calder, and, on the nomination of the Recorders of Sections, Dr. R. C. K. Blundell, the Recorder of Section C (Geology). It is hoped that the setting up of this committee will help, amongst other things, to accelerate the drafting of programmes and to encourage consultation—when it is necessary and appropriate—between Sections and the Council.

12. The Committee of the Division later submitted a second Report on Functions, and this is presented, with the approval of Council, for the information of the General Committee. The Second Report, including the terms of reference of the Programme Advisory Committee, is attached as Appendix I.

13. A number of proposals for the future expansion of the Association's activities arising out of the Second Report are summarised in Appendix II. The Council have given general approval to these proposals, but have at the same time stressed that they cannot be undertaken unless the income of the Association is greatly increased. Among the suggestions considered were proposals for a programme of inter-Meeting activities, liaison with press and broadcasting authorities on the dissemination of science to the public, and for a Junior B.A. Meeting. The Council have endorsed in principle any measures which would promote the well-being of science and science teaching in schools and agreed that detailed consideration of such measures should be deferred until funds for such developments are available.

14. The Council have specifically agreed that the British Association should, if the necessary funds were provided, set up a Study Group to consider the present system of education, and to submit recommendations on the place of science in a balanced school curriculum. It was agreed that this problem should be considered in relation to the needs of the country, and the present shortage of scientists and technologists.

Presentation of Science to the General Public

15. The Council is pleased to report that Sir Ian Jacob, the Director-General of the B.B.C., has agreed to appoint B.B.C. representatives as members of a joint study group to consider the presentation of science to the general public. The Council have appointed the following as their representatives:

Sir Raymond Priestley—Chairman
The General Officers
Sir Lawrence Bragg
Mr. Ritchie Calder
Mr. L. Farrer Brown
Dr. D. C. Martin
Dr. C. F. A. Pantin

The following terms of reference have been laid down:

'The Council of the British Association, being convinced of the need for a better public understanding of the importance of science to the community, and believing that the creation of such understanding demands continuous and authoritative communication of the significance of scientific discovery and its impact upon society, has decided, as a first step, to set up an *ad hoc* Study Group composed of persons appointed by the Association and representatives of the B.B.C. nominated by the Director-General, with the following terms of reference:

1. To make recommendations on the most effective forms of presentation to the *general public* and in particular on the techniques and methods of presentation which could be adopted by the B.B.C., with special reference to presentation by television.
2. To consider suitable subjects for presentation (*a*) to demonstrate to the public that science is interesting and exciting, and offers many opportunities for careers, and (*b*) to demonstrate the impact of science on society.'

The Council are also able to report that it is understood that the B.B.C. propose —when planning their science programmes—to make the week of the Annual Meeting a 'Science Week'.

Membership of the Association

16. Each member of the Association present at the meeting in Sheffield was invited to complete a questionnaire which would enable some analysis of the membership of the Association to be made. It was hoped that such an analysis would make possible more effective planning of the Annual Meetings.

The total attendance at Sheffield was 3,373, and cards asking for information about age, sex, occupation and residence were completely or partially filled in by 2,359 members. Of 924 students attending the Meeting only 436 supplied the required information. The remainder of the group (1014) not returning cards was composed of local members and women.

Among the 1,551 members with professional or scientific qualifications, the five largest groups were engineers (236), educationists (214), chemists (205), geographers (117), and physicists (106). 1799 members stated their age groups, and the middle groups, 26–35 yrs.—(292); 36–45 yrs.—(257); 46–55 yrs.—(313), were all strongly represented, a finding which does not support the statement so often made that the Meetings are only attended by the young and the old. A very high number of the members stating their occupation came from the universities (836), with the schools (455) and industry (325) coming next. As regards place of residence, information was available from all the cards, and the area with the biggest representation was Sheffield, with 843, with London and the Home Counties (505), and the North of England (excluding Sheffield) next.

A detailed analysis of the figures has been prepared.

Officers and Council

17. *President*, 1958—The Council will make a recommendation to the General Committee. [Sir Alexander Fleck, K.B.E., F.R.S., was unanimously elected President for 1958.]

18. *General Officers*, 1957–58.—The Council nominate for reappointment as General Officers for the year 1957–58:

General Treasurer: Mr. M. G. Bennett.

General Secretaries: Dr. George Taylor and Prof. W. Wardlaw, C.B.E.

19. *Other Members of Council*, 1957–58.—The members retiring under Statute III, 3, are: Prof. K. S. Isles, Dr. Willis Jackson, Prof. H. D. Kay, Mr. J. Wickham Murray and Sir William Pugh.

Under the powers given to them by Statute the Council nominate for appointment: Prof. Sargant Florence, Prof. T. Neville George and Dr. R. E. Slade, leaving two vacancies in the ordinary membership to be filled by the General Committee.

The following is the full list of nominations recommended for approval by the General Committee:

J. N. L. Baker
R. J. Bartlett
Prof. L. F. Bates, F.R.S.
Prof. W. Burns
P. Ritchie Calder, C.B.E.
Prof. G. R. Clemo, F.R.S.
Prof. Sargant Florence
Prof. T. Neville George
Sir Ronald Gould
A. C. Hartley, C.B.E.
Prof. H. R. Hewer
Prof. L. Hunter
Rev. Prof. E. O. James
Sir Ben Lockspeiser, K.C.B., F.R.S.
Dame Kathleen Lonsdale, D.B.E., F.R.S.
Prof. A. D. Macdonald
James Macdonald, C.B.E.
Dr. C. F. A. Pantin, F.R.S.
Dr. K. P. Oakley
Dr. R. W. Powell
Dr. H. G. Sanders
Dr. R. E. Slade
Dr. W. E. Swinton
Dr. W. B. Turrill, O.B.E.
Prof. P. E. Vernon
W. H. Wilcockson
Dr. T. Wilson
Prof. S. W. Wooldridge, C.B.E.

[The General Committee approved the above nominations and appointed Sir James Turner and Mr. L. R. Missen, C.M.G., M.C., to fill the remaining vacancies.]

20. *Honorary Auditors*, 1957–58.—The Council appointed Dr. H. G. Maule to fill the vacancy created by the death of Sir John Simonsen. They recommend that Dr. H. J. T. Ellingham and Dr. H. G. Maule be appointed by the General Committee for the year 1957–58.

21. *Professional Auditors*, 1957–58.—The Council recommend the reappointment of W. B. Keen and Co.

Appointment of Secretary

22. The Council report that they have unanimously agreed that the appointment of Sir George Allen, who assumed office as Secretary of the Association on April 1, 1954, for a period of three years in the first instance, be extended for a further two years from April 1, 1957.

General Committee

23. The following have been admitted to membership of the General Committee on the recommendation of Section Committees:

Section B (Chemistry)	Prof. R. D. Haworth
	Prof. F. S. Dainton
	Dr. J. Dewar
	Dr. A. J. Turner
	Dr. A. H. Lamberton
Section C (Geology)	Prof. O. M. B. Bulman
	Mr. K. Coe
Section G (Engineering)	Dr. E. C. Cherry
Section J (Psychology)	Miss I. M. Slade
	Mr. G. Westby
	Mr. D. E. Broadbent

Bristol Meeting

24. The Council have pleasure in reporting that a further sum of £63, being the final balance of the Bristol Local Fund, has been received as a donation from the Bristol Local Committee. The Council wish to record their very deep appreciation of this additional gift, which, together with the sum received in the previous year, has brought the total donation from Bristol to a sum of £463.

Sheffield Meeting

25. The attendance at the Sheffield Meeting was 3,373 members, a figure which included 924 student members. A narrative account of the Meeting appeared on pages 149–55 of the December 1956 issue of *The Advancement of Science*. One of the innovations at the Meeting was the making of a photographic record of the proceedings by the University Film Unit. The Council looks forward to viewing the film when it is completed, and believes that it will not only be a most useful record of the Association's activities, but will also prove to be of great interest to all those who come regularly to the Association's Annual Meetings.

Dublin Meeting

26. The Council wish to express their thanks to their local colleagues for the excellent arrangements they are making for the reception and entertainment of members. The Organising Committee have most generously decided to repeat the offer to each member, first made last year, of a specially designed Member's diary. A symphony concert to be given by the Radio Eireann Symphony Orchestra is being arranged for the evening of Sunday, September 8.

Glasgow Meeting, 1958

27. The General Treasurer and the Secretary of the Association attended a luncheon arranged by the Lord Provost of Glasgow at which an appeal for a Local Fund was initiated. The Council are honoured to learn that the Rt. Hon. the Lord Provost of Glasgow has agreed to act as Chairman, and the Principal of the University as Vice-Chairman, of the Local General Committee. The Council have received from the Local Committee and recommend for acceptance a proposal that the Meeting be held during the period August 27 to September 3, 1958. The following Local Honorary Officers have been appointed:

Treasurer (to be appointed).

Hon. Local Secretaries: Dr. R. Hutcheson, O.B.E., J.P., Registrar of the University: Mr. Tom Weir, the Lord Provost's Secretary.

28. *Presidents of Sections*, 1958.—The following have accepted the Council's invitation to serve as Sectional Presidents at Glasgow:

Section		Section	
A	Dr. T. A. Allibone	H	Dr. I. Peate
B	Prof. H. J. Emeléus	I	Dr. E. N. Willmer
C	Prof. L. R. Wager	J	Prof. R. W. Pickford
D	Dr. A. S. Parkes	K	Prof. R. S. Adamson
E	Prof. Estyn Evans	L	Dr. Willis Jackson
F	Prof. A. J. Brown	M	Dr. D. P. Cuthbertson
G	Prof. O. A. Saunders		

Assembly of Corresponding Societies: The Rt. Hon. Lord Boyd Orr, F.R.S.

The Division for the Social and International Relations of Science

29. The Statutes require the Committee of the Division to be reappointed annually. The Council wish to report therefore that the existing Committee was reappointed under the Chairmanship of Sir Ben Lockspeiser, with the addition of Mr. P. A. Macrory. The membership of the Committee is as follows:

Sir Ben Lockspeiser (*Chairman*)
The President and General Officers
Mr. P. Ritchie Calder
Mr. Blair Cunynghame
Sir Harold Spencer Jones
Prof. H. D. Kay
Sir Hugh Linstead
Mr. J. L. Longland
Dame Kathleen Lonsdale
Mr. P. A. Macrory
Dr. D. C. Martin
Lord Nathan
Prof. Dudley Stamp

Science and Industry Committee

30. The Report of the Science and Industry Committee which was first appointed by the Council in 1952 was published by the Oxford University Press on May 31 under the title 'Industry and Technical Progress'. A synopsis of the Report is submitted by the Council for the information of the General Committee as Appendix III.

The Council wish to report that arrangements have been made to secure suitable press, radio and television publicity for the Report and that two meetings have been planned to discuss the Report, one in London under the auspices of the Royal Society of Arts and one in Leeds under the auspices of the Association. The Council invited a Sub-Committee of the Division for the Social and International Relations of Science to undertake the organisation of the Conference in Leeds. The members of this Sub-Committee were Sir Ben Lockspeiser (Chairman), Mr. M. G. Bennett, Professor C. F. Carter, Mr. P. A. Macrory, and Professor B. R. Williams. Sir Charles Morris, Vice-Chancellor of the University of Leeds, most generously offered his help in making the necessary arrangements and on his advice it was decided to hold the Conference during the first week of July 1957. The Sub-Committee has also arranged, in consultation with Section F (Economics), a discussion on the Report at the Dublin Meeting.

Editorial Committee

31. The Council wishes to report that the Editorial Committee continues to direct its attention to making *The Advancement of Science* increasingly attractive to non-specialist readers and that it has in mind the possibility of eventually publishing a monthly journal in place of the present quarterly. Achievement of this, if the proposal is approved, will depend on the realisation of the financial objectives at present under discussion.

32. The Editorial Committee have also considered the style and make-up of the Preliminary Programme and made a number of recommendations which have been implemented in the Programme for the Dublin Meeting.

33. The Committee have also, after discussion, drawn up the following note for the advice of Recorders of Sections when their Committees are considering which papers should be published in the *Journal*.

'The Committees of Sections should be asked to recommend to the Editorial Committee papers which are not submitted for printing elsewhere for publication in *The Advancement of Science*. In the making their recommendations, Section Committees are asked to give priority to papers which are of interest to workers in other fields and intelligible to the non-specialist. Where it is recommended that special reports and symposia or whole sessions should be published, the Committee concerned should nominate an author who would undertake the preparation of such reports.'

Publications

34. *The Advancement of Science* has been published regularly and maintains a quarterly circulation of some 3,000 copies, of which nearly a quarter are sold to non-members of the Association. The new and improved form introduced in the issue of September 1956 has proved generally acceptable. The Council are pleased to report that the Local Organising Committee in Dublin have decided to produce a 'Scientific Survey of Dublin and its Region' and to make it available free of charge to all members present at the Meeting.

Scientific Films

35. The Council have arranged once again a programme of scientific films; they will be screened daily in the Aula Maxima, Newman House, St. Stephen's Green. The Council are grateful for the support given to them in this work by the British Universities Films Council and the Scientific Film Association, and wish particularly to thank Mr. E. Stafford, who, as the appointed representative of the B.U.F.C., has made all the arrangements for showing the films at Dublin. The Council are indebted also to the Scientific and Technical Group of the Royal Photographic Society of Great Britain for having once again undertaken the planning of a programme of research films for showing at the Meeting.

Memorial Lectures

36. The Council are pleased to report that Dr. H. G. Sanders accepted their invitation to deliver the Lockyer Lecture for 1957.

37. Prof. H. D. Kay was appointed to deliver the Pedler Lecture and he addressed an enthusiastic and representative audience in Cork on April 2, 1957, on the subject of 'Economic production of milk from grassland'. Prof. Kay's lecture was followed by conferences in Cork with members of the Dairy Science Faculty and with representatives of agricultural organisations and agricultural advisers, and by a short tour of farms in the county.

Biological Stations

38. The Council have agreed that the annual grants of £50 for the rent of Tables at Plymouth, Windermere and Naples, should be renewed in 1957. In coming to this decision the Council took note of a resolution put forward from the Sheffield Meeting by the Committee of Section D (Zoology) and supported by the Committee of Section K (Botany), recommending that further publicity for the Tables at Plymouth and Windermere should be sought and that the facilities available should be brought to the notice of the Science Masters Association, the Association of Women Science Teachers and the Principals of Technical Colleges. The Council were of the opinion that it was important to encourage science teachers, members of technical colleges and amateurs to undertake scientific work at marine stations and recognised that that modern grant facilities tended to help the professional university workers rather than the other groups mentioned. It was agreed therefore that the facilities available should be further publicised (and this has been done), and that the question of renewing the annual grants to the Stations should be reviewed in a year's time.

Research Committees

39. Following the Sheffield Meeting, the Council, on the recommendation of Sections, appointed the following nine Research Committees, full details of which are given in *The Advancement of Science*, Volume 13, No. 51, pages 214.

Committee	*Section*	*Grant*
Seismological Investigations	A	—
Critical Geological Sections	C	£30
The Teaching of Geology in Schools	C	—
The Coal Board Flora	C, K	£60
Cytology and Genetics	D, K	—
Geographical Glossary	E	—
Derbyshire Caves	H	£10
Inventaria Archaeologica	H	£10
Ainu of Japan	H	£10

RESOLUTIONS

40. *The Teaching of Geology in Schools.*—The Council wish to report that they have accepted a recommendation from Section C (Geology) that the completed Report on 'The Teaching of Geology in Schools' should be published in *The Advancement of Science* and that 1,000 copies of the Report should be made available in pamphlet form for the use of schools and other interested bodies. Copies of the Report have been distributed free of charge to the Ministry of Education, the directors of local education authorities, the secretaries of teachers' organisations, the secretaries of the chief geological and natural history societies, the directors of museums catering for school visits, and the educational press.

41. *The Biochemical Society.*—In their last Report the Council noted that a resolution had been received from the Committee of the Biochemical Society asking that the institution of a Section of Biochemistry within the Association should be considered. A resolution was received from Section I (Physiology) at the Sheffield Meeting that the title of the Section be changed to Physiology and Biochemistry. The Council, having accepted this suggestion, report that the Council of the Biochemical Society have agreed unanimously to this proposal, which is now therefore in force.

42. *Directory of Natural History Societies.*—The Council have agreed to undertake, at the invitation of the Carnegie United Kingdom Trust, the preparation and publication of a new edition of the *Directory of Natural History Societies.* The Council are of the opinion that the publication of an up-to-date version of this directory will be a valuable contribution to the work of the local, regional and national societies involved and a significant encouragement to the many amateurs in science associated with these societies. They feel especially pleased at being invited to undertake this work because they already have close contact with this field of endeavour through the Assembly of Corresponding Societies, to which are affiliated some 170 local scientific societies, many of them in the field of natural history. The Council wish to record their deep appreciation of the generosity of the Trustees which has enabled them to undertake the work of publication without cost to the Association.

PRIZES

43. *South Africa Medal, 1905.*—The Council is pleased to report that the South Africa Medal for 1956 has been awarded by the South African Association for the Advancement of Science to Dr. R. F. Lawrence.

44. *Endeavour Essay Prize, 1957.*—The Council once again report with gratitude their acceptance of an offer by the publishers of *Endeavour* of prizes for scientific essays. In this, the eighth of the Endeavour Essay Competitions, the subjects set were: 'The International Geophysical Year', 'Science Fiction', 'Irish Contributions to Science', 'Atmospheric Pollution', 'Chemistry and the Conquest of Disease', and 'Particles in Plant and Animal Cells'. The successful competitors were Miss R. J. A. Kirkland (first), Mr. R. B. Cain (second), and Mr. C. M. Elliott (third).

Special prizes for competitors under eighteen years of age were awarded to Mr. G. Benjamin, Miss D. J. Haas and Mr. R. L. Jones.

APPENDIX I

SECOND REPORT ON THE FUNCTIONS OF THE BRITISH ASSOCIATION

1. Introduction

The interim report attempted to define what the policy and functions of the Association in the modern world should be. In doing so it considered the Annual Meeting, activities between meetings, publications, the role of the mass media in communicating science, and the need for adequate funds. It is the intention of this report to amplify this general statement and to suggest ways in which the policy already outlined should be given practical effect.

2. The Annual Meeting

(A) *Programme Planning*

The Council has appointed a Programme Advisory Committee. The suggested terms of reference are given below.

(B) *Addresses by Presidents of Sections*

(i) It has been suggested to the Council that Presidential Addresses should deal with major developments such as recent discoveries of general importance within the field of the Sections, or the reassessment of the principles of a science in the light of recent work, or the future development of a science and its probable influence on related sciences, pure and applied, or the bearing of any of these upon scientific education. It has also been suggested that Presidents might sometimes choose subjects which would set a theme for the Section for the Meeting. It has also been emphasised that it is most important that Presidents of Sections should bear in mind that dissemination of knowledge of science and its methods is one of the prime objects of the Association. Since they will be addressing mixed and not wholly specialist audiences, it is hoped that their Addresses will be couched in language intelligible to specialists in other fields and to informed laymen.

The Council attaches great weight to these suggestions and has decided that they should be brought to the notice of Section Committees and to Presidents of Sections when inviting them to accept office.

(ii) The Council is of the opinion that members should be enabled to hear as many Presidential Addresses and other major items in the Sectional programmes as possible. It agrees therefore that the Programme Advisory Committee, in consultation with the Sectional Committees, should devise means whereby the Presidential Addresses are arranged in appropriate groups according to subject-matter and at times which would enable members to hear all or most of the addresses which interest them. When the Presidential Addresses are so arranged, larger audiences will be able to hear them and integration and dissemination will be fostered.

(C) *Sectional Proceedings*

(i) The Council has considered the criticism that there are too many speakers and is in general agreement with the critics when they say that the programme is too ambitious and that it is not desirable to invite three-hundred or more speakers to participate in the Annual Meeting. The Council also considers that certain communications to the Annual Meeting contain detail of research procedure and data more appropriate for specialist societies. The Council recommends that these views should be submitted to Section Committees for full consideration.

(ii) The Council considers that Sections should be encouraged in every possible way to provide more symposia and to arrange more joint Sessions and to include fewer individual unrelated papers in their programmes. It is also believed that the

interest of symposia and joint Sessions will be enhanced if a discussion can be organised and more time provided for such discussion.

(D) *The Printed Programme*

The Committee recommends that a new section should be added to the printed programme for the Annual Meeting which would contain a list of the major items in the programme arranged in groups, including the Presidential Addresses, Evening Discourses, Public Lectures, symposia and joint Sessions. It is believed that this would be a convenience to the member when planning his own programme for the meeting.

(E) *The Press and the Annual Meeting*

The Press gives more prominence to science during the week of the Annual Meeting than at any other time throughout the year, and the impact on the public is considerable. This impact could, however, be made much more effective if the Association had the resources to prepare for the Press suitable summaries of the proceedings expressed in language which was fully intelligible to the layman. This is a major undertaking and would require suitably qualified staff. There is a strong case for the appointment of a permanent Press Officer who would also be responsible for editing the Association's publications. There is no doubt that this would lead to better reporting and would be a definite contribution in the field of dissemination.

3. The Activities of the Association between Annual Meetings

(i) The British Association is the principal scientific organisation open to laymen as well as scientists, and because of its widely representative membership is well able to consider and report on problems in many related fields, by the appointment of committees. The most recent example of this activity is the Science and Industry Committee. This, however, is only one of many problems which require objective study. The industrial development of recent or comparatively recent discoveries has had far-reaching results, and certain problems have been created which can only be solved by balanced objective study. The Association, because of its membership, is particularly suited to deal with problems relating to the impact of science on society and there is a great need today for authoritative and objective information to be made available to the public. The Committee therefore recommends that the Council should, whenever possible, set up such committees.

(ii) *Conferences.* The Committee recommends that the Council should organise one-day or two-day conferences on scientific subjects of immediate national or public importance, whenever it is apparent that authoritative and objective comment is necessary.

It must be emphasised that the developments suggested in sub-paragraphs (i) and (ii) above cannot be undertaken until the headquarters staff is sufficiently strengthened.

4. The Association and Young People

(i) The Association is already in close contact with the younger generation through its Annual Meeting. Undergraduates, including the holders of exhibitions awarded by the Association, and students selected and assisted by universities and colleges, schoolboys and school girls from the upper forms, attend the Annual Meetings in very large numbers. The average number of student members attending the last three meetings was nine hundred.

The Annual Meetings are attended by many science teachers, and the Schools' Science Exhibitions at the last two Annual Meetings have been of great value.

(ii) It is considered, however, that much more should be done. For example, the shortage of scientists and technologists and of science masters in schools presents

serious problems, and it would be appropriate for the Association to play its part in their solution. There are many questions of great importance. Does the present school curriculum provide a suitable background for a citizen in the world today? Is there too much specialisation to the detriment of a broad education at school? Are the entrance and scholarship requirements at universities affecting school education and the flow of scientists? Will the provision of more facilities in schools for the teaching of science provide the answer to some of these problems or will it be necessary to adopt new and completely different methods to stimulate an interest in science before an adequate number seek scientific careers?

It has been suggested that there is an urgent need for the adoption of a completely new school curriculum which will give every citizen a broadly based education which must include some teaching of the significance of science, and that to enable such a curriculum to be adopted it will be necessary for the universities to revise their entrance requirements to the science faculties and their regulations for scholarship examinations. The Committee recommends that the Council should take steps to ensure that full consideration is given to these views.

(iii) Sir Edward Appleton, in his first Reith Lecture, has said, indeed, 'We can devise the most elaborate eductional apparatus for training our younger scientists, but we have still got to engage the interest of these young folk in scientific careers: our national need will not be met until more young people elect to devote their lives to science.'

It is suggested that the Association could play an important part in stimulating an interest in science in schools by organising special lectures, exhibitions, discussions, 'brain trusts', etc., for schoolchildren in order to demonstrate that science is interesting and exciting as well as offering careers. Meetings and discussions would be of particular value in the areas outside the range of universities and colleges, and there are many of these in this country.

5. Dissemination to the Public

(i) *The Association.* At the present time the impact of the Association on the public is achieved mainly by press reports or broadcasts from the Annual Meeting. The Committee is of opinion that there is an urgent need for objective and authoritative information in intelligible language to be given to the public about the impact of science. Such information can be given in various ways:

(*a*) By lectures, discussions etc., organised by the British Association, to societies, clubs, trade unions, industrial organisations, women's organisations, etc.

The Committee is of opinion that it will probably be necessary to offer fees to lecturers for such work, because it is time-consuming and difficult and it is essential that it should be well done. There is a precedent for payment for special lecturers in the case of the Lockyer, the Pedler and the Mather Lectures. The desirability of charging for attendance at such lectures should also be considered.

(*b*) By the publication of suitable pamphlets and special reports (see also para. 6).

(ii) *The Mass media of communication.* Reference has already been made to the press reports from the Annual Meetings. It is considered that the Press should devote more space to science and in particular to the impact of science on society throughout the year. The Committee recommends that the Association should attempt to impress upon the Press, and particularly upon proprietors and editors, the importance of adopting a continuing policy of presenting science to the public; advising them when necessary about how to get information, and urging the importance of giving their science writers more scope and opportunity. The Committee is also of opinion that radio and television could play a much more important part than they do today in the dissemination of science and that an attempt should

be made to impress those responsible for broadcasting in this country with the importance of science and the need for the public to be given a better understanding of its significance and impact.

6. Publications

It is essential that the proceedings of conferences between Annual Meetings and the reports of special committees should be published if they are to influence public opinion effectively. It is felt, moreover, that there is a great need for a good monthly journal written in language which the non-specialist and the non-scientist can understand. The Committee recommends that the Council be asked to consider the possibility of publishing a monthly Journal instead of the present quarterly and in addition a short one-volume report of the Annual Meetings.

7. Finance

To undertake additional tasks of the sort suggested is beyond the present resources of the Association with its small permanent staff. The Association has in the past been able to keep its working expenses at a low level, but only because the generous hospitality offered by cities has provided a large part of the cost of its Annual Meetings and because it has been loyally and generously served by a large number of unpaid officers.

It should be remembered that while the income of the Association remains fixed at about £11,000 a year, the organisation of the Annual Meeting is becoming more expensive every year, and the costs of publication, too, are rising steadily. The income of the Association from subscriptions, sales of publications, advertising and interest on investments has, in fact, been insufficient to meet the annual recurrent expenditure since the First World War. The average deficit for the years 1948–55 was £797 per annum, and this would have been greater but for certain gifts. The Local Committee in the place of the Annual Meeting raises a fund to meet the local expenses and today a fund of about £10,000 is necessary to make the meeting a success. This amount can only be raised in the larger cities and unless the Association from its own funds can make a substantial contribution to the local expenses, it will not be possible in the future to hold meetings in the smaller cities and towns, which would be most regrettable, as such places derive special benefit from the Annual Meetings.

The Committee recommends that this report be brought to the attention of the Finance Committee and that immediate steps be taken to provide additional funds which will not only enable the present activities of the Association to be adequately financed but will also make possible the suggested extensions of its activities.

PROGRAMME ADVISORY COMMITTEE

Terms of Reference

(i) To convene a meeting of the President, Officers and Presidents and Recorders of Sections as early as possible after the Annual Meetings and not later than the middle of October each year to discuss the general planning of the programmes for the next Annual Meeting. It is believed that such a discussion would facilitiate the work of the Recorders and the Section Committees, as it would provide an opportunity for framing tentative proposals for joint sessions. Each Section would also know at an early date about the preliminary plans of the other Sections. Such a meeting would provide an opportunity to make a provisional assessment of how far the Sections' proposals go to meet the needs of the various groups of members likely to attend the meeting.

It would *not* be a function of this Committee to direct Section Committees, but rather to provide opportunities for discussion between the Officers of all or certain Sections in order that co-ordination should be facilitated, when co-ordination was desirable. If there were subjects of importance which could be included in the programme, but which were not included in the preliminary list of subjects from the Section Committees, it would be appropriate for this meeting to discuss the possibility of including some or all of these in the Section programmes.

Consideration should also be given to the question of how far the proposals for the Sections' programmes would be attractive to scientists as well as fulfilling the functions of integration and dissemination.

(ii) It would be a duty of the Committee to consider the programme as a whole, and if it was found that there was any lack of balance between specialised items, integrating items and popular exposition, to remedy this by arranging for the inclusion of suitable additional items if necessary at special sessions. Provided that when a session was proposed on a subject which would ordinarily be regarded as falling directly within the purview of a Section, the President of the Section concerned should be consulted, and his general agreement obtained before making arrangements for such a session.

It would also be a duty of the Committee to ensure that the programme contained an appropriate number of items of interest to those concerned with the applications of science, and when appropriate to invite industrialists and others to take part in the discussions at any special session arranged by the Committee.

(iii) To arrange, subject to approval by the Council, meetings and conferences between the Annual Meeting in suitable places, to discuss subjects of scientific importance, by appointing *ad hoc* organising committees or by inviting the Division to arrange such conferences, when the subject was considered to fall within the purview of the Division.

(iv) To consider and submit proposals to Council on any matter, not specifically mentioned above, relating to the Association's functions of integration and dissemination.

APPENDIX II

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

A Review of the Proposed Developments

Introduction

The Council of the British Association is discussing ways and means of extending its activities. It is doing so because it is convinced that the more intensive development and rational use of the Country's potential reserves of scientific resource and talent—so vital to the national interest—can only be ensured by increased public understanding of the issues involved. In the creation of such understanding, authoritative, objective and continuous communication of the significance of scientific discovery and its impact on society is, the Council believes, one of the essential factors at the present time.

The Annual Meeting

The overriding purposes of the Association are discussion, integration and dissemination and the great Annual Meetings have played and will continue to play an important part in carrying out these functions. The Council has adopted proposals which will make the Meetings more effective in the future. They include the setting

up of a Programme Advisory Committee, which has been charged with the duty of ensuring that there is in the programme a proper balance between specialised items, integrating items and popular exposition. There are also proposals for making the Meetings still more attractive to young people.

The Annual Meeting however lasts for one week only, and the Association believes that it is essential today that its impact on society should extend throughout the year.

The Supply of Scientists

The Council is concerned in particular about the supply of scientists and technologists, and believes that the British Association could, if it had the necessary resources, play an important part in helping to implement the Government's plans for meeting the present emergency, in bringing home to people in all walks of life the urgency of our need and the dangerous consequences of falling behind other countries in scientific development.

The proposals to create more facilities for teaching science and for training scientists and technologists are an important first step, but it is unlikely that the problem can be solved by the provision of facilities unless the public and in particular parents and young people are given a better understanding of the significance of science and unless the educational system of the country is overhauled to conform with the needs of the present-day world.

The Association could help to stimulate an interest in science:

(i) By organising throughout the year, in suitable centres, special lectures, exhibitions, discussions and 'brains trusts' for young people and parents, societies, clubs, trade unions, industrial organisations, women's organisations, etc. Such meetings and discussions would be of particular value in places outside the immediate range of the universities and colleges.

(ii) By organising a 'Junior B.A. Meeting' with special lectures, demonstrations and exhibitions designed to stimulate the imagination of young people and to stress the adventure of scientific discovery.

(iii) By the publication of suitable pamphlets and special reports.

(iv) By liaison with the press and radio and television services to provide more coverage for science throughout the year.

The Organisation of Inter-Meeting Activities

The success of lectures and meetings will depend mainly on two factors: the preliminary arrangements in the place of the meeting, and the selection of suitable speakers. It is essential in advance of any meeting to secure the support of all local organisations and individuals likely to be interested, and to take steps by suitable publicity, etc., to get a large and representative audience. This will involve visits by a member of the staff to the place of the meeting. The selection of suitable speakers in sympathy with the purpose of the meetings, able to hold the interest of their audiences, and to express themselves in language intelligible to the layman is most important. It will be possible to find such speakers if they are offered adequate fees and expenses.

The Present System of Education

The present system of education has been subjected to criticism during recent years. The view is held by many that while science should be an integral component of any system of education, over-specialisation at school is detrimental to a liberal education which is so necessary today. It is held, too, that the entrance and scholarship requirements of the universities interfere with the adoption of a more liberal scheme of education.

There have been many discussions of this problem, but no satisfactory solution has been proposed, and it is essential that an attempt should be made to find one without delay. Time is against this country, and any new scheme cannot be effective until four to five years have elapsed from the date of its introduction. The British Association, because of its representative membership, and its close association with universities, schools, research institutions and industry, is well qualified to play a part in seeking a solution.

It is proposed, therefore, that the British Association should set up a study group to consider the views that have been expressed and to submit recommendations on the place of science in a balanced school curriculum.

APPENDIX III

INDUSTRY AND TECHNICAL PROGRESS

(*Report of the Science and Industry Committee*)

It has for a long time been widely believed that British brilliance in pure science is not matched by enough speed and ingenuity in its industrial application. The belief is not fair to the best of British industry; but much backwardness remains, and a country so hard pressed in its economic affairs cannot afford to lose time in applying scientific and technical knowledge. With this in mind, the British Association, at its Belfast meeting in 1952, appointed a committee 'to study the problems of speeding up in industry the application of the results of scientific research', and it was joined in this work in 1954 by the Royal Society of Arts and the Nuffield Foundation. Generous support was available under the Conditional Aid programme, and the committee was able to set up research units at the University College of North Staffordshire and at the Queen's University, Belfast. The first fruits of the work is a book published by the Oxford University Press on May 31, under the title *Industry and Technical Progress* (by C. F. Carter and B. R. Williams; price 25*s*.).

The purpose of this book is to identify the things which help or hinder the application of science in industry. It is based in part on recent case-studies in British industry, and it fully confirms both the wide range of British industrial practice and the great changes in the attitude to science which have taken place of recent years. There are therefore no generalisations to be made about 'British industry', and no simple and outstanding causes of technical backwardness. The report suggests that technical backwardness is in fact commonly the expression of an attitude or habit of mind, which is shown also in other failings—for instance, secretiveness, poor management practices, ineffective recruitment policy and weak salesmanship. Twenty-four general characteristics, identified in technically progressive firms, were found to be usually absent in the unprogressive. The change from backwardness to progressiveness, therefore, is not usually just a question of removing an obstacle which stands in the path of a firm otherwise keen to move forward; it is a problem of changing the attitude and practice of the firm in many matters which cover a much wider field than its technique of production.

This does not mean that particular obstacles to speedier progress are of no account; their removal may be a necessary condition of advance, even if it is not a sufficient condition. The book discusses at some length problems of the availability of finance and the effects of high taxation, and although it does not support some of the stronger claims about the financial handicaps of British industry, it tries to show just where these money matters may be important. There is also an examination of a shortage ultimately more crucial than that of money, the shortage of able

and appropriately trained minds, and some questions are raised about the effectiveness of the British educational system and about the efficiency with which skills in short supply are used by industry. Other matters which might be considered as obstacles are looked at in the light of the evidence from the case-studies and from special investigations; for instance, restrictive practices, the small size of the British market, different forms of management and industrial organisation, and Government controls. Some of these do not appear to have great significance, and their elimination helps to concentrate attention on more important matters.

One of these is the importance of interconnections between firms in stimulating progress and spreading technical knowledge. Allied to this is the fact that technical progress may require the simultaneous advance of an interrelated group of firms, and the sluggishness of one may hold up all. Some firms are proud of their self-sufficiency; the most perfect vehicles for the communication of technical knowledge pass them by, for they are not organised or equipped to reach out and take what is offered to them. Such parochial firms may cause delays far beyond their own industries. At the other extreme are firms in which research and development has found its proper place as a management technique, and which are organised to develop and use scientific advances, and to pull in new knowledge from all over the world.

The final paragraph of the text of the book refers to two findings, one encouraging, the other showing the magnitude of the difficulties which remain. 'We find that technical progressiveness is to some extent related to financial success, and in particular that it may pay to be first in the field, rather than to allow the pioneering to be done by others. If these findings are correct the forces of natural selection, stimulating the growth of profitable firms, are allied to those of technical progress. But on the other hand we suggest that backwardness is self-perpetuating, both in firms and industries; the backward firm, even if it can be made to desire technical progress, is ill placed to command the resources (and in particular the human ability) necessary to begin that progress. It will take much ingenuity by industry and government to break up the crust of habit and to divert lively and able minds from the places where change is most likely to those where it is most needed.'

DUBLIN MEETING
SECTIONAL TRANSACTIONS

Any references to publication supplied by authors will be found in the list below. References indicated by 'cf.' are to appropriate works quoted by the authors of papers, not to the papers themselves.

SECTION A

MATHEMATICS AND PHYSICS

September 5

The physics of cloud and rain :

Dr. B. J. Mason.—*Recent developments in the physics of rain and rain-making.*
Article to appear in *Times Sci. Rev.*; cf. 'The Physics of Clouds', Clarendon Press (1957).

Mr. R. J. Murgatroyd.—*Cloud physics investigations from aircraft.*
Cf. R. J. Murgatroyd, 'Cloud physics at the Meteorological Research Flight', *Arch. Met., Wien*, Serie A, Band 8, Heft 3, p. 246 (1955); R. J. Murgatroyd, 'Meteorological Research in Aircraft', Air Ministry Meteorological Research Committee, M.R.P. No. 955 (1956).

Mr. W. Macklin.—*Cloud seeding experiments in Australia.*

September 6

Stellar energy and stellar evolution, Presidential Address by Prof. T. G. Cowling, F.R.S.

Industrial applications of thermonuclear reactions :

Mr. J. D. Lawson.—*Nuclear fusion as a possible source of power.*
Account to appear in *Nature*; *Electrical Times*, Sept. 12 issue, contains a comprehensive summary; cf. papers by W. B. Thompson (*Proc. phys. Soc. Lond.* B, **70**, p. 1, 1957) and J. D. Lawson (same journal, p. 6).

Sir George Thomson, F.R.S.—*Controlled thermonuclear reactions.*
Account of paper (with J. D. Lawson's paper) written by J. D. Lawson, to appear in *Nature.*

September 9

Dr. F. D. Kahn.—*Recent work on the Crab nebula.*
Account to appear in *New Scientist*, Oct. 1957.

Dr. R. L. F. Boyd.—*Observations of solar radiation from rockets.*

Dr. H. von Klüber.—*A solar magnetograph* (presented by Mr. D. W. Beggs).

Dr. H. Elliot.—*Cosmic rays from the Sun.*

September 10

Exploration of the deep ocean floor :
Account to appear in *Nature.*

Mr. R. D. Adams.—*Seismic prospecting of the ocean floor.*
Account to appear in *Nature.*

Dr. A. S. Laughton.—*Exploration of the ocean floor by echo-sounder and camera.*
Account to appear in *Nature*; cf. (1) A. S. Laughton, 'A new deep-sea underwater camera', *Deep-Sea Res.* **4**, 120–5 (1957); (2) A. S. Laughton, 'Photography of the deep-sea floor', *Discovery*, **18**, 59–62 (1957).

Mr. A. A. Smales.—*Neutron activation analysis of 'cosmic' spherules from marine sediments* (Read by Mr. D. Mapper).
Cf. (1) A. A. Smales, D. Mapper & A. J. Wood, 'Radioactivation analysis of cosmic and other magnetic spherules', *Geochim. et cosmoch. Acta* (in the press); (2) A. A. Smales, D. Mapper & A. J. Wood, 'The determination, by radioactivation, of small quantities of nickel, cobalt and copper in rocks, marine sediments and meteorites', *The Analyst*, **82**, 75 (1957); (3) A. A. Smales & J. D. H. Wiseman, 'Origin of nickel in deep sea sediments', *Nature*, **175**, 464 (1955).

Dr. Robert S. Deitz.—*Deep sea research by bathyscaph.*
Account to appear in *Times Sci. Rev.*, Winter Issue.

September 11

Prof. J. D. McGee.—*Application of photoelectronic devices to astronomical problems.*
Cf. (1) 'Photo-electric aids to photography', *J. Brit. Kinematogr. Soc.* **30**, No. 6 (June 1957); (2) 'Photo-electronic problems in Astronomy', Symposium. University of Pennsylvania, Philadelphia, U.S.A. (June 1956).

Dr. E. J. Öpik.—*Artificial satellites.*
Expanded version to appear in *Irish Astron. J.*, Sept.–Dec. issue, 1957.

SUB-SECTION A *

MATHEMATICS

September 5

Dr. M. A. Jaswon.—*Applications of elementary mathematics to the theory of crystal lattices.*

Mr. J. M. Hammersley.—*Percolation processes.*

Prof. J. L. Synge, F.R.S.—*How stands the theory of gravitation to-day?*

September 9

The history of mathematics:

Prof. C. Lanczos.—*The striving for rigour in Greek science.*
Nature, **180**, No. 4591, pp. 843–4 (Oct. 26, 1957).

Dr. A. J. McConnell.—*Hamilton and his contribution to mathematics.*

Prof. P. M. Quinlan.—*Solution of non-linear differential equations by Step functions.*

SECTION B

CHEMISTRY

September 5

Chemical approaches to the investigation of lung cancer, Presidential Address by Dr. J. W. Cook, F.R.S.

September 6

Biogenesis of natural products:

Sir Robert Robinson, O.M., F.R.S.—*Biogenesis or structural relations: the organic chemist's contribution.*

Prof. A. J. Birch.—*Acetic acid as a building unit in the formation of mould products.*
Summary in *Nature*, **180,** No. 4588, p. 679 (Oct. 5, 1957); to appear in *Proc. chem. Soc. Lond.* and *Chem. & Ind.* (*Rev.*).

Prof. T. S. Wheeler.—*Biogenesis of flavonoids.*
Account to appear in *Nature*, *Chem. & Ind.* (*Rev.*), *Proc. chem. Soc., Lond.*

Prof. T. R. Seshadri.—*Biogenesis of natural products.*

Dr. G. J. Popják.—*The biogenesis of sterols.*
Cf. (1) J. W. Cornforth, G. D. Hunter & G. Popják, 'The biosynthesis of cholesterol from acetate', *Arch. Biochem. Biophys.* **42,** 481 (1953); 'Studies in cholestreol biosynthesis: 1. A new chemical degradation of cholesterol', *Biochem. J.* **54,** 590 (1953); '2. Distribution of acetate carbon in the ring structure', *Biochem. J.* **54,** 597 (1953). (2) G. Popják, 'Biosynthesis of squalene and cholesterol *in vitro* from acetate-1-^{14}C', *Arch. Biochem. Biophys.* **48,** 102 (1954). (3) J. W. Cornforth & G. Popják, 'Studies on the biosynthesis of cholesterol. 3. Distribution of ^{14}C in squalene biosynthesized from [Me-^{14}C] acetate, *Biochem. J.* **58,** 403 (1954). (4) J. W. Cornforth, G. Popják & I. Youhotsky Gore, 'Further studies on the biosynthesis of cholesterol and squalene', in *Biochemical problems of lipids*, p. 216, Butterworths Scientific Publications, London (1955); 'Studies on the biosynthesis of cholesterol. 4. Degradation of rings C and D', *Biochem. J.* **65,** 94 (1957). (5) G. Popják, 'Chemistry, biochemistry and isotopic tracer technique', Royal Institute of Chemistry; *Lectures, Monographs and Reports*, 1955, No. 2. (6) J. W. Cornforth, R. H. Cornforth, G. Popják & I. Youhotsky Gore, 'Biosynthesis of squalene and cholesterol from DL-β-hydroxy-β-methyl-δ-[2-^{14}C]valerolactone', *Biochem. J.* **66,** 10P (1957). (7) R. G. Gould & G. Popják, 'Biosynthesis of cholesterol *in vivo* and *in vitro* from DL-β-hydroxy-β-methyl-δ-[2-^{14}C] valerolactone', *Biochem. J.* **66,** 51P (1957).

September 9

Biology of Yeast. (See entry under Section K.)

Making and breaking polymer molecules:

Dr. L. Bateman.—*The mechanico-chemistry of polymers.*

Prof. H. F. Mark.—*Stereospecific polymerisations.*

Dr. C. H. Bamford.—*Synthetic polypeptides as models for natural proteins.*
To appear in *Nature*; cf. *Synthetic Polypeptides*, by Bamford, Elliott & Hanby, Academic Press Inc., New York (1956); *Proc. roy. Soc.* A, **236,** 384 (1956) (Ballard & Bamford, 'Chain Effect') and Downie, Elliott, Hanby & Malcolm in the *Proceedings of the Royal Society* (in the press).

Dr. C. W. Bunn.—*Plastics for use: designing molecules for particular purposes.*

The new element 102

Mr. H. A. C. McKay.—*The new element 102.*
Letter in *Phys. Rev.*, Sept. 1957 (probably); paper to appear in *Nature.*

Dr. J. Milsted.—*The new element 102.*
Letter in *Phys. Rev.*, Sept. 1957; summary to appear in *Nature*, article to appear in *Times Sci. Rev.*

September 10

Chemistry in the service of agriculture:

Mr. A. W. Marsden (Chairman).—*Introduction: The role of chemistry in production.*
Cf. 'Future trends in agricultural production', *Chem. & Ind.* (*Rev.*), Nov. 3, 1956, pp. 1252–7.

Mr. J. W. Parkes.—*The fertiliser industry in Ireland.*

Dr. T. Walsh.—*The chemical evaluation of soil fertility.*

Dr. P. W. Brian.—*Plant hormones.*
Cf. article to appear in *Times Sci. Rev.*; P. W. Brian & J. F. Grove, 'Gibberellic acid', *Endeavour*, **XVI,** No. 63, pp. 161–71 (July, 1957).

SECTION C

GEOLOGY

September 5

The geology of the region:

Prof. J. C. Brindley.—*An outline of the geology of south-east Ireland: Pre-Cambrian to Devonian.*

Prof. W. D. Gill.—*The geology of Eastern Ireland: Carboniferous and post-Carboniferous.*

Mr. M. V. O'Brien.—*Economic geology of Ireland.*

September 6

Caledonian Granites:

Prof. H. H. Read, F.R.S.—*The Caledonian Granite series in general.*
To appear in *Sci. Progr.* during 1958.

Prof. H. H. Read, F.R.S.—*The Donegal Granite series in particular.*

Prof. J. C. Brindley.—*The Leinster Pluton and associated granitic rocks.*

Mr. K. Coe.—*Plutonic geology of the Mount Leinster district.*

Carboniferous stratigraphical palaeontology:

Dr. R. G. S. Hudson.—*The faunal subdivisions of the Dinantian.*

Prof. T. Neville George.—*Visean facies and zones.*

Dr. W. E. Nevill.—*Carboniferous stratigraphical palaeontology of Irish midlands.* To appear in *Proc. R. Irish. Acad.* 1958.

Dr. J. S. Jackson.—*Carboniferous Coelacanth fishes of Ireland.*

Sedimentation and sedimentary structures:

Prof. W. D. Gill.—*Slumping and sedimentation in the Namurian of Co. Clare.*

Dr. J. E. Hemingway.—*Torridonian sedimentation and sedimentary structures.*

In the absence of Dr. Whiteman a written contribution from Prof. P. G. H. Boswell, F.R.S. on *Intraformational disturbances: an appeal to reason*, was read on his behalf by the President of the Section.

September 9

Lower palaeozoic vulcanicity:

Ordovician volcanoes, Presidential Address by Dr. G. H. Mitchell, F.R.S.

Dr. J. C. Harper.—*The age of the Ordovician vulcanicity in eastern Ireland.*

Mr. G. J. Murphy.—*Mid-Ordovician vulcanicity in S.E. Ireland.*

Cf. forthcoming publication on the Geology of the Tramore Area, Co. Waterford, to appear in the *Proc. R. Irish Acad.*, probably as three (or more) separate papers dealing respectively with: (*a*) the Stratigraphy (with generalised references to (*b*) and (*c*)); (*b*) Palaeontology; (*c*) Igneous and Tectonic History. It is hoped that paper (*a*) will appear in 1958.

Mr. N. S. Angus.—*A Granite-Diorite complex in the Tyrone Igneous series.*

September 10

The geomorphology of Ireland. (See entry under Section E.)

Pre-Cambrian rocks of Ireland and their correlation with the U.K.:

Mr. J. W. Baker.—*The metamorphic rocks of S.E. Co. Wexford.*

Dr. A. E. Currall.—*The Dalradian sequences of the S.W. end of Ox Mountains, Co. Galway.*

Prof. R. M. Shackleton.—*The Connemara schists.*

Prof. J. G. C. Anderson.—*Moinian and Dalradian — South Mayo to South Donegal.*

Cf. 'The Occurrence of Moinian Rocks in Ireland', *Quart. J. geol. Soc. Lond.* **103,** 171–90 (1948); 'Stratigraphical Nomenclature of Scottish Metamorphic Rocks', *Geol. Mag.* **85,** 89–96 (1948); 'Les Subdivisions et les Correlation de L'Antecambrien', Comptes Rendus de la XIXème Session, Congrès Géologique International, Fasc. 1, pp. 9–19 (1953); 'The Pre-Cambrian Rocks of the Slieve League Promontory, Co. Donegal', *Quart. J. geol. Soc. Lond.* **109,** 399–422 (1954). It is also expected to publish further in J. G. C. Anderson (1958), 'The Geology of the Croagh Patrick District, Co. Mayo' (submitted to *Quart. J. geol. Soc. Lond.*).

Dr. W. S. Pitcher.—*The Dalradian rocks in N.W. Donegal.*

September 11

Miscellaneous original papers:

Dr. R. N. Cope.—*Silurian sedimentation and faunas in northern Co. Tipperary (Devilsbit Mountain district).*

Prof. A. Williams.—*Implications of brachiopod migration during Ordovician times.*

Mr. A. Fowler.—*The Kinbane volcano.*

Dr. N. Rast, Mr. B. A. Sturt, and Mr. A. L. Harris.—*The metamorphic zones in central Perthshire.*

SECTION D

Zoology

September 5

The evolution of organisation in the nervous system, Presidential Address by Prof. J. Z. Young, F.R.S. (read by Prof. E. J. W. Barrington).

The structure and functioning of the nervous system:

Mr. W. K. Taylor.—*Theories of functioning of the nervous system investigated by an electronic analogue computor.*

Cf. W. K. Taylor, 'Electrical Simulation of some Nervous System Functional Activities', (Information Theory, Third London Symposium, edited by Colin Cherry, published by Butterworths Scientific Publications, 1956); W. K. Taylor, 'Measurement and Control in the Human Operator', *Trans. Soc. Instrum. Tech.* Vol. **9,** No. 3, Sept. 1957.

Dr. J. W. S. Pringle, F.R.S.—*The analysis of nerve function.*

Dr. H. P. Whiting.—*The organisation of the nervous system in primitive vertebrates.*

Cf. *Quart. J. micr. Sci.* **98,** (2), 163 (June 1957); *Quart. J. micr. Sci.* **89,** 359 (1948).

Dr. D. M. Vowles.—*Structure and function in the insect nervous system.*

Dr. M. J. Wells.—*Touch discrimination in the octopus.*

Cf. M. J. Wells & J. Wells (1956), 'Tactile discrimination and the behaviour of blind *Octopus*', *Pubbl. Staz. zool. Napoli*, **28,** 94–106; M. J. Wells & J. Wells (1957a), 'The function of the brain of *Octopus* in tactile discrimination', *J. exp. Biol.* **34,** 131–42; M. J. Wells & J. Wells (1957b), 'The effect of lesions to the vertical and optic lobes on tactile discrimination in *Octopus*', *J. exp. Biol.* **34,** 378–93.

September 6

Chemical transmission in invertebrates and vertebrates. (See entry under Section I).

Biological aspects of cancer:
Nature, **180**, No. 4591, pp. 830–2 (Oct. 26, 1957).

Prof. A. Haddow.—*Introduction.*

Prof. E. S. Horning.—*Hormones and cancer.*

Dr. A. Glucksmann.—*Cancer as a problem of cell differentiation.*

Dr. E. H. Mercer.—*The electron microscope and cancer.*

Dr. R. J. Goldacre.—*The reaction of the cell membrane of* Amoeba proteus *with carcinogens.*

Dr. M. Abercrombie.—*Cancer as a problem of the control of cell movement.*
Cf. M. Abercrombie & Joan E. M. Heaysman (1954), 'Observations on the social behaviour of cells in tissue culture. II. "Monolayering" of fibroblasts', *Exp. Cell Res.* **6**, 293–306; M. Abercrombie & Joan E. M. Heaysman (1954), 'Invasiveness of sarcoma cells', *Nature*, **174**, 697.

Dr. G. C. Easty and Dr. D. M. Easty.—*Specificity of normal and malignant cells* (Illustrated by a film).

Prof. P. C. Koller.—*Chromosome variation and cell polymorphism in malignant growth.*
Cf. *Proc zool. Soc., Calcutta*, Mookerjee Memor. Vol., 81–93 (1957).

Prof. A. Haddow.—*The general biology of cancer.*

September 9

Radiation and biology. (See entry under Section K.)

Parasitic worms:

Prof. J. D. Smyth.—*The 'in vitro' approach to helminth biology.*
Cf. D. M. Archer & C. A. Hopkins (1957), 'Studies on cestode metabolism. III. The growth pattern of *Diphyllobothrium* sp. (Cestode: Pseudophyllidea) in a definitive host', *Exp. Parasit.* (in the press); E. J. Bell & C. A. Hopkins (1956), 'The development of *Diplostomum phoxini* (Strigeida, Trematoda)', *Ann. trop. Med. Parasit.* **50**, 275–82; J. D. Smyth (1950), 'Studies on Tapeworm Physiology. V. Further observation on the maturation of *Schistocephalus solidus* (*Diphyllobothriidae*) under sterile condition *in vitro*', *J. Parasit.* **36**, 371–83; J. D. Smyth (1954a), 'Studies on Tapeworm Physiology. VII. Fertilization of *Schistocephalus solidus in vitro*', *Exp. Parasit.* **3**, 64–71; J. D. Smyth (1956a), 'Studies on Tapeworm Physiology. VIII. Occurrence of Somatic Mitosis in *Diphyllobothrium* spp. and its use as a criterion for assessing growth *in vitro*', *Exp. Parasit.* **5**, 260–70; J. D. Smyth (1956b), 'Studies on Tapeworm Physiology. IX. A histochemical study of egg-shell formation in *Schistocephalus solidus* (Pseudophyllidea)', *Exp. Parasit.* **5**, 519–40; E. J. Bell & J. D. Smyth (1957), 'Cytological and histochemical criteria for evaluating development of trematodes and pseudophyllidean cestodes *in vivo* and *in vitro*', *Exp. Parasit.* (in the press).

Mr. D. L. H. Robinson.—*'In vitro' studies on* Schistosoma mansoni.
Cf. *J. Helminth.* Vol. **XXIX**, No. 4, pp. 193–202 (1956).

Prof. R. M. Gordon.—*Migrations of parasitic helminths.*

Dr. P. H. Silverman.—*Biology and control of the human beef tape-worm.*

General and marine zoology:

Prof. J. Brontë Gatenby and Mrs. Gouri Ganguli.—*Notes on the New Zealand glow-worm.*

Prof. G. P. Wells, F.R.S.—*Temperature and the geographical distribution of lugworms* (Arenicola).

Mr. D. I. D. Howie.—*The spawning stimulus in marine annelid worms.*
To appear in *J. exp. Biol.*

Dr. L. lePage Renouf.—*Further changes at Lough Ine.*

Films on Animal Behaviour:
The programme included films presented by, or on behalf of, Dr. Stuart Smith, in collaboration with Mr. George Edwards and Mr. Eric Hosking (*Aggressive displays of some birds*), Dr. W. H. Thorpe, F.R.S. (*The work of the Cambridge University Ornithological Field Station at Madingley*), and Dr. N. Tinbergen (*The begging response of chicks of the Black-headed Gull*).

September 10

The biology of the salmon:

Dr. A. E. J. Went.—*Salmon investigations in Ireland with particular reference to the River Shannon.*
Cf. *Irish Salmon and Salmon Fisheries*, published by Edward Arnold for the Buckland Foundation (1956).

Miss Eileen Twomey.—*The age and growth of salmon in Ireland.*

Mr. E. D. Toner.—*Movements of salmon in the sea around Ireland.*

Mr. A. Swain.—*Factors affecting the downstream migration of salmon and sea trout.*

September 11

Mr. C. F. Hickling, C.M.G.—*Fisheries development in the colonial territories.*

SECTION E

GEOGRAPHY

September 5

Dublin and its Region:

Mr. J. P. Haughton.—*Dublin and its region.*
Cf. 'The site of Dublin', *Irish Geogr.* **11**, No. 3 (1946); 'The Social Geography of Dublin', *Geogr. Rev.* **XXXIX**, No. 2 (1949).

Dr. A. Farrington.—*The geomorphology of the Dublin region.*

September 6

Dr. Monica Cole.—*The Savannas of Brazil. The everlasting hills*, Presidential Address by Prof. David L. Linton.

September 9

The geography of Ireland (*i*) *population studies:*

Mr. T. W. Freeman.—*Population decline and landscape change in rural Ireland since 1845.*

Cf. previous papers in *Geogr. J. Geogr. Rev., Econ. Geogr., J. of the Statistical and Social Inquiry Society of Ireland; Ireland* (Methuen, 1950), *Pre-Famine Ireland* (Manchester University Press, 1957).

Mr. Stuart H. Cousens.—*The pioneer fringe in Ireland after the great famine 1851–1861.*

Mr. Richard Lawton, *Irish immigration to England and Wales in the mid-19th century.*

Dr. Joy Tivy and Dr. James R. Caird.—*South Uist: a Scottish congested district.*

The geography of Ireland (*ii*) *studies in historical geography:*

Dr. J. H. Andrews.—*Some seventeenth century records of the Irish landscape.*

Mr. T. Jones-Hughes.—*East Leinster in the mid-19th century.*

To appear in *Irish Geogr.* **III,** No. 5, (1958).

Mr. R. H. Buchanan.—*Rural change in an Irish townland 1890–1955.*

September 10

The geomorphology of Ireland:

Mr. G. L. Davies.—*Irish erosion surfaces —a statistical analysis.*

Mr. J. B. Whittow.—*The structure of the southern Irish Sea area* (read by Prof. A. Austin Miller).

Mr. N. Stephens.—*The evolution of the coastline of north-east Ireland.*

Mr. V. B. Proudfoot.—*Peat and peat-soils in Northern Ireland.*

September 11

The geography of under-developed lands:

Mr. Peter Haggett.—*Industrial concentration versus regional stability.*

Mr. R. Mansell Prothero.—*Problems of population mapping in an under-developed area.*

SECTION F

Economics

September 5

Mr. H. H. Liesner.—*The European Common Market and British industry.*

The balance-of-payments problems of a European free trade area, Presidential Address by Prof. J. E. Meade, C.B.

Discussion of the Report of the Science and Industry Committee: Chairman, Mr. Seán Lemass, T.D.

Prof. C. F. Carter.—Summary of the conclusions of the report.

Discussion opened by the Rt. Hon. Lord Pakenham and Mr. C. K. Mill.

September 6

Meeting of the Statistical and Social Inquiry Society of Ireland, at the Royal Irish Academy.

Mr. James Meenan.—*Economic incentives.*

September 9

Problems of economic development:

Mr. A. D. Knox.—*Economic development: some problems of underdeveloped countries.*

To appear in *Advanc. Sci.*

Mrs. Ursula K. Hicks.—*Obstacles to development in South Asia, India, Pakistan and Ceylon.*

Account to appear in *Westminster Bank Rev.*, Nov. 1957.

General M. J. Costello.—*Possibilities of development in Ireland.*

Prof. Eric Nash.—*Economic problems of the Caribbean.*

September 10

Prof. E. M. Fisher.—*Economic aspects of urban land use patterns.*

Mr. I. M. D. Little.—*The economist in Whitehall.*

Cf. 'Economist in Whitehall', *Lloyds Bank Rev.*, April 1957.

SECTION G

Engineering

September 5

Session A

Sir Josiah Eccles, C.B.E.—*Energy and power supply.*

To appear in *Engineering*; cf. 'Energy and Power Supplies', *Proc. Instn elect. Engrs*, **102,** Part B, No. 1 (January 1955).

Prof. O. A. Saunders.—*Engineering problems associated with heat transfer.*

Engineering, **184,** No. 4774, p. 313 (1957).

Session B

Mr. J. C. I. Dooge.—*Irish contributions to rainfall-runoff studies.*

To appear in *Engineering.*

Prof. M. A. Hogan.—*Mining development in Ireland.*

Abstract in *Engineering*, Oct. 18, 1957, p. 488.

September 6

Education and training for the engineering industry, Presidential Address by Sir David Anderson.

September 9

Session A

Mr. W. H. Stephens.—*Advances in aeronautics.*
Engineering, Oct. 11, 1957.

Dr. J. Hawthorn.—*Food processing and canning.*
Engineering, pp. 386–9 (Sept. 27, 1957).

Session B

Papers by young engineers:

Mr. J. O'Callaghan.—*Crop conservation practice.*
Cf. (1) 'Through Drying of Deep Beds of Wheatgrain', *Engineer, Lond.* **198,** 817 (1954); (2) 'The Effect of Humidity on Through Drying of Wheatgrain', *Trans. Instn chem. Engrs, Lond.* **33,** 135 (1955); (3) 'Contra-Flow Drying of Beds of Wheat', *J. Sci. Fd Agric.* **7** (II), 721 (1956); (4) 'Development of a Contra-Flow Grain Drier', *J. agric. Engng Res.* **2** (3), 192.

Mr. J. A. N. Lee.—*The stiffening effects of two-edge beams on a Right Slab bridge.*

Mr. D. J. Rowley.—*Equivalent circuits, and their application to induction motors.*
Engineering, Sept. 27, 1957.

Mr. R. S. Wignall.—*Recent trends in electric traction.*

September 10

Session A

Dr. A. D. Booth.—*Computing in the modern world.*

Mr. R. J. Halsey, C.M.G.—*A survey of developments in tele-communications.*
Engineering, p. 432 (Oct. 4, 1957); cf. M. J. Kelly, Sir Gordon Radley, G. W. Gilman & R. J. Halsey, 'A Transatlantic Telephone Cable', *Proc. Instn elect. Engrs*, **102,** Part B, No. 2 (March 1955); Two papers forming part of the Symposium on the Transatlantic Telephone Cable, *Proc. Instn elect. Engrs*, **104,** Part B, Supplement No. 4 (January 1957); E. T. Mottram, R. J. Halsey, J. W. Emling & R. G. Griffith, 'Planning and Overall Performance', and R. J. Halsey & J. F. Bampton, 'System Design for the Newfoundland–Nova Scotia Link'.

Session B

[*with Section M (Agriculture)*]

Mr. R. Paterson.—*The influence of machinery developments on farm organisation.*

Mr. C. Culpin.—*Development in equipment for green fodder conservation.*

SECTION H

Anthropology and Archaeology

September 5

Ancient Ireland (i) field archaeology:

Mr. G. D. Liversage.—*The Mesolithic cultures of Ireland.*

Dr. Joseph Raftery.—*Crannog research in Ireland.*

Dr. M. de Paor.—*Tara.*

Archaeology as science: purposes and pitfalls, Presidential Address by Prof. C. F. C. Hawkes.

September 6

Ancient Ireland (ii) craftsmanship and art:

Mr. H. W. M. Hodges.—*Irish Bronze Age metal craftsmanship.*

Discussion opened by Mr. Breandán Ó Ríordáin.

Prof. M. J. O'Kelly.—*The ancient Irish method of smelting iron.*

Dr. M. de Paor.—*Early Christian Irish metalwork.*

September 9

Ancient agriculture in Ireland and north-western Europe:

Mr. H. C. Bowen.—*Introduction to the study of ancient field systems.*

Mr. F. A. Aberg.—*Introduction to the study of ancient ploughs and plough irons.*
To appear in *Gwerin* under title 'Early Ploughs in Europe', Dec., 1957.

Mr. V. B. Proudfoot.—*Ancient Irish field systems.*

Discussion opened by Prof. M. V. Duignan.

September 10

Irish folk-life:

Mr. A. T. Lucas.—*Horn and corn in Ireland down the ages.*

Mr. C. Ó. Danachair.—*House and farmyard.*
Cf. 'The Irish Traditional House', Report of the International Congress of European & Western Ethnology, Stockholm, 1951 (1956), 4 pp.; 'Stand und Aufgaben der Hausforschung in Irland', Bericht des Arbeitskreises für deutsche Hausforschung (Schleswig, 1955) (1956), 29–50, 22 pp. illustrated; 'Three House Types', *Ulster Folklife*, **2,** 22–6 (1956), 5 pp. illustrated; 'Irish Farmyard Types', *Studia Ethnographica Upsaliensia*, **XI,** 6–15 (1956), 10 pp. illustrated; 'The Bed Outshot in Ireland', *Folk-Liv.*, 1955–56, 26–31, 6 pp. illustrated; 'Materials and Methods in Irish Traditional Building', *J. R. Soc. Antiquaries of Ireland*, 1957, 61–74, 14 pp.

Mr. J. H. Johnson.—*Murphystown: a deserted Irish village.*
Cf. J. H. Johnson, V. B. Proudfoot & R. H. Buchanan, 'Excavations at Minerstown, Co. Down—Preliminary Report on Excavations in 1956', to be published in *Ulster J. Archaeol.* (3rd series), **20,** (1957); the remainder of the paper will be published in the same journal, during 1958.

Discussion opened by Dr. I. C. Peate.

The present state of folklore studies in these islands:

Mr. S. Ó Sullivan.—*Collection and classification of folklore in Ireland and the Isle of Man.*

Mr. S. F. Sanderson.—*Folklore studies in Scotland.*

Mr. Peter Opie.—*Folklore studies in England and Wales.*

Dr. I. C. Peate.—*Folklore studies in Wales.* To appear in *Folk-Lore.*

Discussion opened by Prof. J. H. Delargy.

September 11

Irish blood-group studies:

Dr. E. Hackett.—*Irish blood-group studies.*

Discussion opened by Prof. E. Keenan.

The making of the Irish people:

Prof. J. J. Tierney.—*The Celts and the classical historians.*

Dr. Eoin MacWhite.—*The archaeological evidence.*

Cf. 'Problems of Irish archaeology and Celtic philosophy', *Zeitschrift für Celtische Philologie* **25,** 1–29 (1955).

Prof. Myles Dillon.—*Indo-European and pre-Indo-European elements in Irish.*

Cf. 'The Archaism of Irish Tradition', *Proc. Brit. Acad.* **XXXIII** (1947); 'Celtic and the Other Indo-European Languages', *Trans. phil. Soc.* 1947, 15 (*corrigenda ib.* 1955, 114).

Prof. David Greene.—*The Irish literary evidence.*

Discussion and summing up by Prof. C. F. C. Hawkes.

SECTION I

Physiology and Biochemistry

September 5

The liberation of chemical transmitters:

Chemical transmission at nerve endings, Presidential Address by Prof. Sir Lindor Brown, C.B.E. Sec. R.S.

Dr. Catherine O. Hebb.—*Chemical transmission in the central nervous system.*

Summary published in *Nature,* **180,** No. 4587, p. 627; cf. article in *Physiol. Rev.,* April 1957.

Dr. H. Blaschko.—*Metabolism of adrenaline and* nor-*adrenaline.*

Cf. H. Blaschko, 'Formation of catechol amines in the animal body', *Brit. med. Bull.* **13** (3), 162–5 (1957); H. Blaschko, 'Metabolism and storage of biogenic amines', *Experientia,* **13,** 9–12 (1957); H. Blaschko, Jean M. Hagen & P. Hagen, 'Mitochondrial enzymes and chromaffin granules', *J. Physiol.* (in the press).

September 6

Chemical transmission in invertebrates and vertebrates:

Nature, **180,** No. 4587, p. 627 (Sept. 28, 1957).

Dr. D. B. Carlisle.—*The neuro-humoral control of the heart in crustaceans.*

Dr. O. F. Hutter.—*Mode of action of autonomic transmitters on the vertebrate heart.*

Dr. Paul Fatt.—*Inhibitory action in crustacean muscle and in the vertebrate central nervous system.*

Dr. J. S. Gillespie.—*The release and subsequent inactivation of the chemical transmitter at adrenergic nerve endings.*

Cf. G. L. Brown & J. S. Gillespie (1957), 'The output of sympathetic transmitter from the spleen of the cat', *J. Physiol.* **138,** 81–102.

September 9

Radiation and biology. (See entry under Section K.)

Electrolyte exchange in cells:

Prof. E. J. Conway, F.R.S.—*Energy and form in the living cell.*

Dr. D. Hingerty.—*Hormonal control of electrolyte metabolism.*

Dr. M. G. Harrington.—*The question of ion transport in mitochondria.*

September 10

The infant animal:

Dr. R. A. McCance and Dr. E. M. Widdowson.—*The physiology of the newborn animal.*

Lancet, Sept. 21, 1957; account in *Nature,* Oct. 5, 1957.

Mr. G. A. Lodge.—*The nutrition of young pigs.*

Summaries have appeared in the *Farmer & Stockbreeder* of Sept. 17, 1957 (**71,** No. 3543, p. 99), and in *Nature* (**180,** No. 4588, p. 681).

Dr. J. H. B. Roy.—*The nutrition of the early weaned calf.*

A report of the paper 'The Nutrition of the Early Weaned Calf', given at Dublin, appeared in the 'Constitution and Care of the Infant Animal', *Nature, Lond.* **180,** 681 (1957). An unabridged version will probably appear in *Dairy Sci. Abstr.* in due course.

September 11

Underwater swimming and diving:

Nature, **180,** No. 4592, pp. 883–6 (Nov. 2, 1957).

Dr. H. J. Taylor.—*Physiological problems in diving and underwater swimming.*

Nature, Nov. 2, 1957.

Capt. W. O. Shelford.—*Modern diving apparatus.*

Mr. F. Dumas.—*Summing up, illustrated by films.*

SECTION J

Psychology

September 5

Clinical psychology and related topics:

Dr. P. J. R. Dempsey.—*A projective test of insight.*

Dr. S. G. Laverty.—*Sodium amytal and extraversion.*

Dr. H. Steinberg.—*Some psychological effects of drugs.*

Cf. Hannah Steinberg & A. Summerfield, 'Influence of a depressant drug on acquisition in rote learning', *Quart. J. exp. Psychol.* **9**

138–45 (1957); A. Summerfield & Hannah Steinberg, 'Reducing interference in forgetting', *Quart. J. exp. Psychol.* **9,** 146–54 (1957); S. E. Dicker, Hannah Steinberg & R. H. J. Watson, 'Effect of methylpentynol on the activity of rats', *J. Physiol.* **137,** 88–89P (1957); S. E. Dicker & Hannah Steinberg, 'Actions of methylpentynol in man', *Brit. J. Pharmacol.* (in the press).

The worker and his work, Presidential Address by Dr. H. G. Maule.

Psychological and occupational aspects of ageing:

Prof. L. S. Hearnshaw.—*Introduction.*

Mr. D. B. Bromley.—*Some recent studies of the effects of age on intellectual processes.*

Mr. K. F. H. Murrell and Mr. S. Griew.—*Age and industrial performance.*

Cf. K. F. H. Murrell & S. Griew, 'Age and industrial performance', *World Sci. Rev.* Nov. 1957, 10; K. F. H. Murrell, S. Griew & W. A. Tucker, 'Age structure in the engineering industry: a preliminary study', *Occup. Psychol.* **31,** 150–68 (1957).

September 6

The psychologist in the community:

Dr. G. Seth.—*The challenge to psychology.*

Dr. C. B. Frisby.—*The psychologist in industry.*

Dr. W. D. Wall.—*The psychologist in education.*

Dr. John McKenna.—*The psychologist in the Child Guidance Service.*

Miss M. A. Davidson.—*The psychologist in the Health Services.*

Research papers on incentives and communications in industry:

Mr. C. A. Oakley.—*Introduction.*

Mr. R. Sergean.—*Decision-taking and the presentation of information.*

Miss S. B. N. Shimmin.—*Workers' understanding of incentive payment systems.*

Account in *Times Rev. Ind.*, October 1957. It is proposed to submit the full text of the paper to *Occup. Psychol.* for publication.

Mr. Leslie Buck.—*The effectiveness of group wage incentives.*

September 9

The educational, psychological and administrative problems of bilingualism. (See entry under Section L.)

Dr. T. Renshaw.—*Education as a science.*

Mr. A. E. Maxwell.—*The measurement of attitudes.*

Mr. S. W. Anthony.—*Reasoning in rats.*

Cf. Dr. J. A. Deutsch & W. S. Anthony, 'Blocking the incorrect alley in a two-drive learning situation', to appear in May 1958, *Quart. J. of exp. Psychol.*

Dr. R. J. Audley.—*Probability models for the description of learning behaviour.*

Cf. R. J. Audley, 'A Stochastic description of the learning behaviour of an individual subject', *Quart. J. exp. Psychol.* **IX,** 12–20 (1957); R. J. Audley & A. R. Jonckheere, 'Stochastic processes and learning behaviour', *Brit. J. stat. Psychol.* **IX,** 87–94 (1956).

Dr. C. J. C. Earl.—*Consciousness in subnormals.*

Social concomitants of achievement in training and education:

Dr. S. Wiseman.—*Educational attainment and social factors:* 1. *The home environment.*

Dr. F. W. Warburton.—*Educational attainment and social factors:* 2. *The school environment.*

Mr. A. B. Cherns and Mr. K. W. Tilley.—*Social factors in the training of Royal Air Force boy entrants.*

Dr. M. L. Kellmer Pringle and Miss Victoria Bossio.—*Learning difficulties of deprived children.*

Cf. 'Educational needs of deprived children,' *Child Care,* **XI** (1957); Miss V. Bossio and M. L. Kellmer Pringle, 'A study of deprived children'. Pt. I: 'Intellectual, emotional and social development'. Pt. II: 'Language development and reading attainment', to appear in *Int. J. Human Development,* 1958.

September 10

Perception and skilled performance:

Mr. Roy Davis.—*Channelling of auditory and visual information.*

Cf. R. Davis (1956), 'The Limits of the "Psychological Refractory Period"', *Quart. J. exp. Psychol.* **8,** 24–38; R. Davis (1957), 'The Human Operator as a single channel information system', *Quart. J. exp. Psychol.* **9,** 119–29.

Mr. D. E. Broadbent.—*The role of attention in skill, with a mechanical analogy.*

Dr. J. A. Leonard.—*Specifying stimulus characteristics for visual tasks.*

Mr. J. Annett.—*Perceptual organisation in simple skills.*

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Dr. A. M. Uttley.—*Mechanisms which learn from past experience.*

Cf. (1) A. M. Uttley, 'The classification of signals in the nervous system', *Electroenceph. clin. Neurophysiol.* **6,** 479–94 (1954). (2) A. M. Uttley, 'Conditional Probability Machines and Conditioned Reflexes', in *Automata Studies* (ed. Shannon and McCarthy) (1956), Princeton University Press. (3) A. M. Uttley, 'Temporal, and Spatial Patterns in a Conditional Probability Machine', in *Automata Studies* (ed. Shannon and McCarthy) (1956), Princeton University Press.

Mr. P. Ladefoged and Mr. D. E. Broadbent.—*Perceptual experiments using synthetic speech.*

Cf. Peter Ladefoged & D. E. Broadbent, 'Information conveyed by vowels', *J. acoust. Soc. Amer.* **29,** No. 1, pp. 98–104 (1957);

D. E. Broadbent & Peter Ladefoged, 'On fusion of sounds reaching different sense organs', *J. acoust. Soc. Amer.* **29**: No. 6, pp. 708–10 (1957).

Mr. T. P. Patton.—*Sensory sensitivity and auxiliary stimulation.*

Miss Catherine Bateson.—*The Israeli Kibbutz.*

Dr. J. L. Zajac.—*Some investigations on perception of movement and on depth phenomena connected with it.*

To appear in *Acta psychol., Amsterdam*; Abstract of paper published in Sixth Yearbook (1955–56), Polish Society of Arts and Sciences Abroad.

SECTION K

BOTANY

September 5

Aspects and problems of conifer embryology, Presidential Address by Prof. J. Doyle.

Prof. R. Florin.—*The systematics of podorarpaceae.*

September 6

Ecology of peat and peat afforestation:

Rev. J. J. Moore, S.J.—*Survey of Irish Boglands.*

Mr. M. E. S. Morrison.—*The ecology of a raised bog in County Tyrone.*

Cf. M. E. S. Morrison (1955), 'The Water Balance of the Raised Bog', *Irish Nat. J.* **XI,** 303; M. E. S. Morrison & A. L. K. King (1956), '*Sphagnum imbricatum* Hornsch. ex Russ.', *Irish Nat. J.* **XII,** 105; 'The Ecology of a raised bog in Co. Tyrone, N. Ireland', to appear in *Proc. R. Irish Acad.*

Mr. R. E. Parker.—*Ecological problems arising in the afforestation of peat land in Northern Ireland.*

Mr. K. F. Parkin.—*Afforestation of peatlands in Northern Ireland.*

Historical background of the Irish flora:

Prof. K. Jessen.—*The interglacial deposits of Gort, Co. Galway.*

Expected to appear in *Proc. R. Irish Acad.* (Dublin).

Dr. R. G. West.—*English glacial periods, interglacial periods and interglacial vegetation.*

Cf. R. G. West (1955), 'The Glaciations and Interglacials of East Anglia: a summary and discussion of recent research', *Quaternaria*, **II,** 45–52; R. G. West (1956), 'The Quaternary deposits at Hoxne, Suffolk', *Phil. Trans.* B, **239,** 265–356; R. G. West (1957), 'Interglacial deposits at Bobbitshole, Ipswich', *Phil. Trans.* B, **241,** 1–31.

Mr. W. A. Watts.—*Interglacial deposits at Kilbeg and Newtown, Co. Waterford.*

Prof. D. A. Webb.—*Atlantic species with disjunct areas: a re-examination.*

September 9

Radiation and biology:

Nature, **180,** No. 4587, pp. 628–30 (Sept. 28, 1957).

Mr. J. L. Putman.—*The physical basis of radioactivity.*

Cf. W. J. Whitehouse & J. L. Putman, 'Radioactive Isotopes', Ox. Univ. Press (1953); J. L. Putman, 'A Review of Application of Isotopes to Engineering', *Proc. Instn. mech. Engrs, Lond.* **170,** 1173 (1956); 'Radioisotopes in Industrial Research and Process Control', *J. Inst. Chem.*, Dec. 1956, p. 694.

Dr. N. G. Trott.—*Radioactivity—its hazards and benefits to health.*

Nature, **180,** 629 (Sept. 27, 1957), in the report of the Symposium, Radiation and Biology; cf. W. K. Sinclair & N. G. Trott, 'The construction and measurement of beta-ray applicators for use in ophthalmology', *Brit. J. Radiol.* **29,** 15 (1956); N. G. Trott & B. M. Wheatley, 'Tantalum-182 wire gamma-ray applicators for use in ophthalmology, *Brit. J. Radiol.* **29,** 13 (1956); D. W. Smithers, D. M. Wallace & N. G. Trott, 'The use of radioactive isotopes in the treatment of patients with bladder tumours', Chapter 15 of *Therapeutic Uses of Artificial Radioisotopes*, ed. Hahn, published J. Wiley & Sons, N.Y. (1956); S. Kramer, L. K. Burton & N. G. Trott, 'Radioactive isotopes in the localisation of brain tumours', *Acta radiol.* **46,** 415 (1956); N. G. Trott, 'Radioactive isotopes in medicine: techniques and equipment', *The New Scientist*, **2,** (31), 32 (1957).

Mr. R. M. H. Whitehouse.—*Radiation induced mutations in crop improvement.*

Cf. 'Progress in Radiobiology', report in book form of proceedings of Int. Congress in Radiobiology, 1955.

Dr. T. C. Carter.—*Levels of radioactivity and mutation in man.*

Biology of yeast:

Prof. E. J. Conway, F.R.S.—*Cell structure and function in yeast.*

Prof. D. G. Catcheside, F.R.S.—*Recent advances in yeast genetics.*

Dr. R. Davies.—*Biochemistry of yeast fermentation.*

Mr. R. B. Gilliland.—*Yeast biology in relation to fermentation techniques.*

Natural plant growth substances:

Prof. T. A. Bennet-Clark, F.R.S.—*The role of hormones in tropic responses of shoots.*

Prof. L. J. Audus.—*Growth substances in root growth.*

Prof. J. Heslop Harrison.—*Auxin and flower sexuality.*

Mr. H. W. B. Barlow.—*Hormones and fruit tree growth.*

Abridged form published in *The Commercial Grower* under title 'Hormones and Fruit Tree Growth', (Sept. 27, 1957), p. 543.

Semi-popular lecture:

Dr. P. Clinch.—*Viruses.*

Cf. Scientific Proceedings of the Royal Dublin Society.

September 10

Photosynthesis:

Dr. G. E. Fogg.—*Actual and potential yields of photosynthesis.*

Account to appear in *Nature.*

Dr. C. P. Whittingham.—*The mechanism of photosynthesis.*

Account of symposium to appear in *Nature*; cf. 'Chloroplast structure and energy conversion in photosynthesis', *Progr. Biophys.* **7**, 319–43 (1957).

Dr. S. R. Elsden.—*The properties of photosynthetic bacteria.*

September 11

Ecology of grasslands:

Dr. C. E. Hubbard.—*Genetical and ecological variation of the components of grasslands in the British Isles.*

Prof. M. J. Gorman.—*Effect of biotic factors on natural and semi-natural grassland.*

Dr. R. F. Hunter.—*The pasture-animal relationship on hill grazings.*

Dr. J. King.—*Some aspects of the ecology of* Nardus stricta.

SUB-SECTION K *

FORESTRY

September 5

Forestry in Ireland, Chairman's Address by Mr. T. McEvoy.

September 6

Ecology of peat and peat afforestation. (See entry under Section K.)

September 9

Forest management and silviculture in underdeveloped areas:

Dr. F. C. Hummel.—*Yield regulation and forecasts of production.*

To appear in *Irish For.*

Mr. D. A. Francis.—*Aerial photography and forestry.*

Mr. T. Clear.—*Some experiences in the survey and assessment of growing stock for forest management purposes.*

September 10

Economics of forestry:

Mr. W. E. Hiley, C.B.E.—*Economics in forest management.*

To appear in *Quart. J. For.*, Jan. 1958.

Mr. E. R. Huggard.—*Roads for economic timber extraction.*

Mr. O. V. Mooney.—*Pinus contorta.*

SECTION L

EDUCATION

September 5

Educational developments in Ireland (with particular reference to vocational schools):

Rev. T. P. Dunning.—*The development of vocational education in Ireland.*

Mr. Sean O'Ceallaigh.—*Education for commerce and management in Ireland.*

Mr. Martin Cranley.—*Technical and technological education in Dublin.*

September 6

The education of the countryman, Presidential Address by Mr. L. R. Missen, C.M.G., M.C.

The special problems connected with the training of women and girls for scientific, technological and technical work:

Mrs. C. E. Arregger.—*A survey of the present situation and a consideration of the steps to be taken if women are to make the fullest possible contribution to the national need for more scientific and technical workers.*

To appear in *The Schoolmaster*; cf. 'Opportunities for Girls and Women in Science and Technology', published for British Federation of University Women (editor, Mrs. C. E. Arregger).

September 9

The educational, psychological and administrative problems of bilingualism:

Rev. Prof. E. F. O'Doherty.—*Bilingualism.*

Sir Ben Bowen Thomas.—*An administrator's approach to the implementation of a bilingual educational policy.*

Mr. John R. Morrison.—*Bilingualism: some psychological aspects.*

September 10

Fundamental education:

Prof. Lionel Elvin.—*Fundamental education and adaptation to a modern way of life.*

Mr. Alec Dickson, M.B.E.—*Idealism and Technical Assistance—misgivings and mistakings.*

September 11

Science and the cultural background of education:

Mr. R. R. Hancock.—*The contribution of the Sixth Form to contemporary society.*

Prof. J. J. McHenry.—*Science in education.*

SECTION M

AGRICULTURE

September 5

The role of agriculture in the British economy, Presidential Address by Sir James Turner.

Dr. J. N. Greene.—*Irish agriculture and its interdependence with British agriculture.*

September 6

Dr. Alan Stewart.—*The development of the modern dairy cow.*

Cf. 'The Development of the Dairy Shorthorn in Britain', *J. R. Agric. Soc.* **3,** (1950).

Mr. J. N. Ritchie, C.B.—*Animal health in relation to Britain's food supplies.*

To appear in *J. Dep. Agric. Dublin*; cf. 'A brief review of those animal diseases for which legislative provision is made in Great Britain', *Brit. vet. J.* **109,** 217 (1953); 'The Control of Foot-and-Mouth disease in Great Britain', *Canad. J. comp. Med.* **17,** 379 (1953); 'Control of Bovine Tuberculosis in Cattle', W.H.O. Monograph Series, No. 19 (1953), 'Advances in the Control of Zoonoses', p. 25 (also issued as F.A.O. Agricultural Studies, No. 25); 'Reglementation du commerce international des viandes', O.I.E. The Report of the XXIst Session, **XL,** May 1953, p. 319; 'The part played by the State in Controlling Animal Diseases', *Advanc. Sci.* No. 40, 369 (1954); 'Eradication of Bovine Tuberculosis', *J. Fmrs' Cl., Lond.* Part 6 (1955).

Dr. Joan Munro.—*Observations of sleep in sheep.*

Cf. 'Sleep in sheep', *Proc. Brit. Soc. Animal Production* (1957), pp. 71–5.

September 9

Radiation and biology. (See entry under Section K.)

Sir Frederick Brundrett, K.C.B., K.B.E. *Agricultural co-operation and technical progress.*

Dr. T. Walsh, Mr. E. Quinn and Mr. P. J. O'Hare.—*The use of peatland in Irish agriculture.*

Mr. T. W. Freeman.—*Modern land use problems in Ireland.*

September 10

Mechanisation in agriculture. (See entries under Section G.)

The infant animal. (See entry under Section I.)

September 11

The ecology of grasslands. (See entry under Section K.)

SECTION X

ASSEMBLY OF CORRESPONDING SOCIETIES

September 5

Mr. Michaél Ó Ruadháin.—*Human ecology and nature conservation studies.*

Prof. J. Heslop-Harrison.—*Some novel fields for field studies.*

The vasculum and the microtome: the relationship between natural history and laboratory biology, Presidential Address by Prof. D. A. Webb.

Dr. A. E. J. Went.—*Fishes in Irish history.*

September 6

(with Section H)

Mr. George B. Thompson.—*Folk culture and the people.*

Discussion on Mr. Thompson's paper, opened by Mr. A. T. Lucas.

September 9

Rev. P. G. Kennedy, S.J.—*Bird watching in Dublin Bay.*

Major R. F. Ruttledge.—*Migration of birds at the Great Saltee, Co. Wexford.* (Film by Mr. John Weaving).

September 10

Irish folk-life. (See entry under Section H.)

Science, by the upper form:

Nature, **180,** No. 4589, pp. 730–2 (Oct. 12, 1957).

Rev. Dr. Michael T. Casey, O.P.—*Introduction: science in our Irish schools.*

Cf. account in *Nature,* **180,** No. 4589, pp. 730–2 (Oct. 12, 1957); *C.T.S. Quarterly, Dublin* (in press).

Mr. J. D. Gallivan.—*The Rev. Dr. Callam of Maynooth, pioneer of electrical research.*

Cf. *Nature,* **180,** No. 4589, pp. 730–2 (Oct. 12, 1957).

Miss V. Poynton.—*Round Dublin in the steps of a marine biologist.*

Mr. J. R. Tinker.—*Bird reserves.*

Nature, **180,** No. 4589, p. 732.

Miss C. D. Smyth.—*Geological tour in the neighbourhood of Dublin.*

The present state of folk-lore studies in these islands. (See entry under Section H.)

ADVANCEMENT OF SCIENCE, SEPTEMBER, 1957

PRESIDENTIAL ADDRESS BY MR. L. R. MISSEN, C.M.G., M.C.

CORRIGENDUM

Page 135, paragraph 3, line 8: *for* "753" *read* "2,753" and, line 11, *for* "three thousand" *read* "twelve hundred".

ADDENDUM

Page 139, paragraph 1: to follow the figures for agricultural machinery between 1942 and 1954:

From the recently published Census of Agricultural Machinery in England and Wales, which compares figures for 1954 and 1956, the following trends are especially significant:

Tractors—8 per cent increase.
Milking machines—15 per cent increase.
Combine harvesters—47 per cent increase.
Grain dryers—117 per cent increase (partly accounted for by the exceptionally wet summer of 1956).
Pick-up balers—90 per cent increase.

(percentage figures are approximate only)

The number of farm wagons and carts declined by approximately 36 per cent, while the number of farmyard manure spreaders rose by 54 per cent. Other sources show that there has been a considerable rise in the number of sugar beet harvesters, so much so that whereas only 1 per cent of the crop was harvested mechanically in 1946, in 1956 the proportion was more than 50 per cent.